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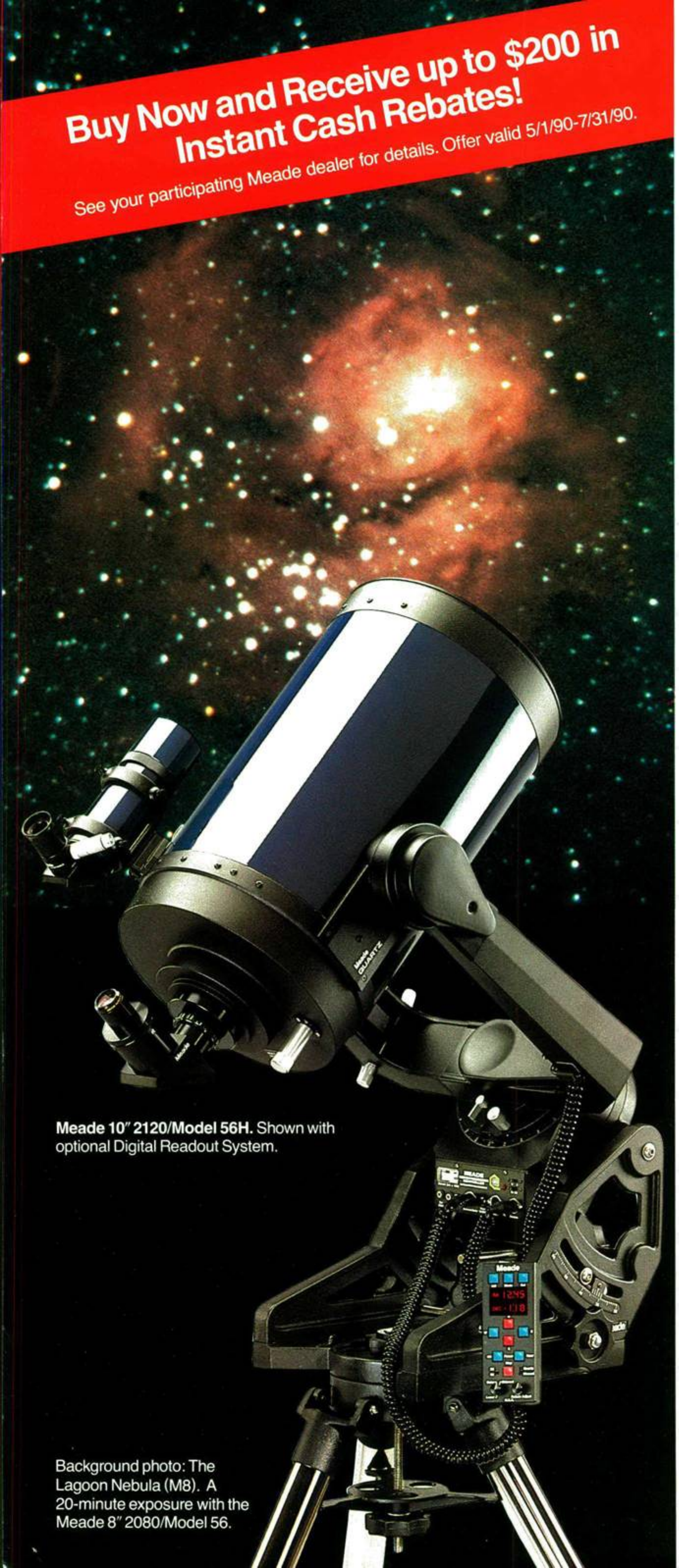

Meade 10″ 2120/Model 56H. Shown with optional Digital Readout System.

Background photo: The Lagoon Nebula (M8). A 20-minute exposure with the Meade 8″ 2080/Model 56.

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Genesis Owner Turned Into Zombie!

Gentlemen:

I would like to say a few words about my new Genesis. I live in a relatively light polluted area, and own an 8" SCT which I have used for about two years. During this time there have been many deep sky objects which I have been unable to locate from my back yard.

I bought Genesis because I wanted a telescope that I could set up quickly to use at home on week-nights. When I began using Genesis, a few weeks ago, I was surprised to find many objects that have eluded me during the past two years. I was even more surprised when I realized that I had been looking in the right places all the time. These objects showed up in Genesis, but not in my 8" SCT.

My back yard experience with Genesis encouraged me to take it to my dark sky observing site which is, at an elevation of 5000 feet above sea level, in the Sierra Nevada Mountains. What I saw there was, in many cases, better than photographs in magazines. I was able to resolve globular clusters to a greater degree than publications indicate.

I didn't expect Genesis to be this good. It really is better than I imagined.

There does seem to be one problem with Genesis. My short week-night observing sessions have become anything but short, and I frequently arrive at work feeling and looking very much like a zombie. I guess that no telescope can solve all of your problems. In any case, thanks for the ones you did solve.

- George N. Storm, California

Photo by Jim Riffle

Unsolicited comments from warranty cards

- *It's beautiful, from case to scope.* C.C. The Netherlands
- *Fantastic! Great photo resolution, best optics ever owned and I'm a Hasselblad & Nikon fan. Now my best item.* D.B. New Jersey
- *This is my 1st scope and I'm having a wonderful time finding the limits of the instrument and my locating abilities.* G.P. New Jersey
- *Very pleased with your new improvements.* J.F. California
- *Even though cost was more than an 8" SCT with mount, quality & convenience won out. I will only use Tele Vue optics, mount and accessories.* W.B. Indiana
- *The telescope lives up to its expectation.* T.W. England
- *Wanted a 2nd telescope that was portable, delivered wide fields and superb images. Genesis is all I hoped for. The sharpness is astonishing and it's very portable.* G.H. Canada
- *Sold my 8" SCT looking for better images.* P.F. New York
- *Fantastic! My wife could not see Trapezium etc. with old scope. Now can't get her away from eyepiece: you have right to be enthused about your product.* W.J. Canada
- *I just wanted to have one excellent telescope to do astrophotography. Fantastic. Awesome.* J.J. California
- *Beautiful equipment - Total satisfaction with first use. Keep up the good work.* M.C. Ohio
- *I wanted a very high quality refractor. I was told by many - "This is it." This is a beautiful instrument!* M.F. Florida
- *Remarkable! I always wanted a 4" fluorite refractor. Sold my (8" SCT).* T.S. Indiana
- *Compactness & quality - a beautiful, fantastic instrument.* J.V. The Netherlands

- *It's the best 4" refractor made.* A.A. California
- *I was looking for the best first telescope I could buy. Something small. I never saw images clearer and more distinct than in Genesis.* G.D. Canada
- *Genesis is the only scope in the race. I wanted the best and believe I got it.* E.S. Australia
- *As the apparent equal of a (Maksutov), with the added RFT capability, Genesis is 'the', to me, obvious choice for portable astronomy. I'm completely satisfied.* R.A. Georgia
- *Very Impressive - my first view was of Pleiades with a 40mm Wide Field. The observation was remarkable, crisp, bright and jewel-like.* P.L. Massachusetts
- *The best on the market.* E.B. England
- *I bought this telescope without having seen it in-person, based on its specification & your reputation for quality. As usual, I got more than I expected with Tele Vue products...* K.L. Texas
- *My friend borrowed it & won't give it back!!* T.L. Canada
- *I wanted portability and very high quality optics. I have waited many years to be able to afford this telescope, - it was worth waiting for.* P.H. Australia
- *Superior to other 4" scopes on offer.* Z.V.S. South Africa
- *Had SCT, poor contrast/resolution. Tele Vue just the opposite, also it's more portable.* W.S. Connecticut
- *I purchased this instrument because:*
  1) Apo-refractor - basic design
  2) Tele Vue reputation
  3) Dealer owns same model
  U.B. Canada
- *Genesis is as good as gold...Maybe better!* F.G. California
- *I compared specs of Tele Vue vs (other high performance refractors); T-V best choice for $.* R.A. New Hampshire
- *Magic.* C.H. England

My sincerest thanks to all who've written us with such kind comments. I look forward to reading yours.

Al Nagler

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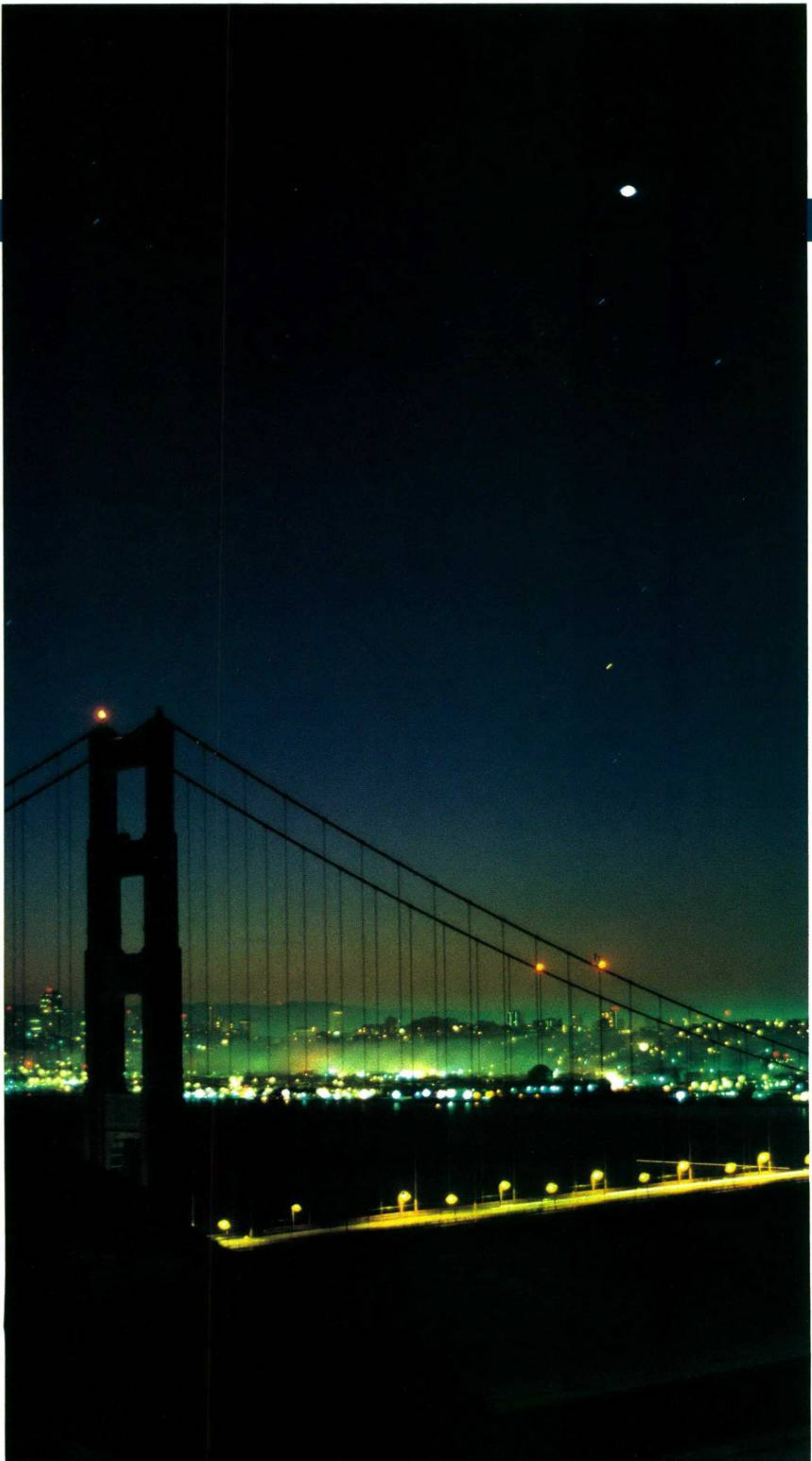
ON THE COVER: Astronomers have strong evidence that explains how spiral galaxies, such as M101 in Ursa Major, can keep spiraling for billions of years without winding up. (See page 28.) Canada-France-Hawaii Telescope Corporation photo.



VENUS AND SCORPIUS make an appearance over San Francisco's Golden Gate Bridge. Despite bright lights, astronomy can still be enjoyed in the city. (See page 70.) Photo by Jim Baumgardt.

ASTRONOMY®

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The Audit Bureau

Behind the Scenes

WELCOME ABOARD!

Greetings to ASTRONOMY's new subscribers. In the last three months thousands of you joined the ranks of amateur astronomers with ASTRONOMY magazine. I'd like to welcome you and spend a few minutes to show you around the magazine.

Our lead story this month describes the mind-boggling implications of new and precise measurements of the cosmic background radiation. Join us in the excitement as astronomers struggle to learn how the lumps of matter we know as galaxies formed from an ultrasmooth primordial fireball. Jeff Kanipe wrote our story which begins on page 20.

If your interest in astronomy runs to stargazing and you live in a city or its suburbs, you have two options: observe from your own backyard or drive out of town to dark skies. In the story that begins on page 70, you'll learn how much astronomy you can do from home. On page 60 take some tips from a veteran deep-sky observer who drives many miles from home to enjoy those incredible star-filled desert skies.

Take a look at our Sky Almanac page, too. Here you'll find a monthly catalog of celestial things to see and do. If you want some pleasant evening stargazing, read Deborah Byrd's Eye On the Sky column that starts on page 44. (Debbie writes and produces the award-winning Star Date radio show heard on many stations around the country.) If you're a telescope user, Rick Shaffer's Through the Eyepiece column will give you a month's worth of observing projects.

We at ASTRONOMY believe in listening to our readers — after all, you're the only reason we're here. For example, ASTRONOMY's readers asked us for an in-depth examination of refractors in the 4-inch-aperture range. We're pleased to report our findings in this issue. The news is great: All four telescopes passed our tough examination with flying colors. The story begins on page 52.

If you're new to ASTRONOMY magazine, let me repeat an offer I've made many times before (if you're an old-timer, please bear with me). Please let us know what you like (and don't like) in ASTRONOMY. Drop us a postcard or a letter. If you're in the Milwaukee area, drop by and see us. The bottom line is that ASTRONOMY belongs to you — the readers — and our goal is to deliver a magazine that meets your approval each and every month.

Clear Skies,

Richard Berry

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Letters

The God Factor

In his Forum article in the March 1990 issue, Philip Stahl suggested that the investigation of a "supernatural entity" might be beyond the domain of science. That would be true if, and only if, the supernatural entity exerted no influence on what we see as physical phenomena. If such an entity does influence the behavior of what we see as matter, then surely its existence could be investigated through the "fossils" of that influence. — *John L. Dobson, San Francisco, California*

One of Carl Sandburg's poems begins with the memorable description of fog "coming in on little cat's feet." A meteorologist could surely provide a technically precise description of how fog rolls in, just as an astronomer could describe how the Big Bang occurred and the universe evolved. But the Book of Genesis provides a beautiful poetic description of the event simply by stating, "And then there was light."

If I were forced to choose between the two, I would have to say that choosing both answers would allow me to agree with Stahl's concluding thought, that "maybe, just maybe, this objective truth and the believers' God are one and the same thing." — *Mansfield W. Williams, Hobe Sound, Florida*

Whatever one thinks of Philip Stahl's conclusions about the existence or nonexistence of God, his logic is delightfully ingenious. The "God factor," he says, "is uniquely individual because each of us sees a different view through our personal window on the cosmos." All observations, including scientific ones, take place through the perceptual "windows" of individual persons. Is this sufficient reason to conclude that any particular kind of observation is merely "individual?"

"Faith," according to a definition that Stahl accepts, "is not constituted of elements that can be dissected or quantified, which relieves the religious person from having to defend every belief on a rational or scientific basis." But it is not just religious beliefs that cannot be "dissected or quantified." For instance, because my belief that Stahl exists cannot be "dissected or quantified," does this relieve me of the responsibility of finding reasons for my belief?

"No human mind," Stahl observes, "is 100 percent perfect, so no human mind is capable of knowing an absolute." But can you think of a more abso-

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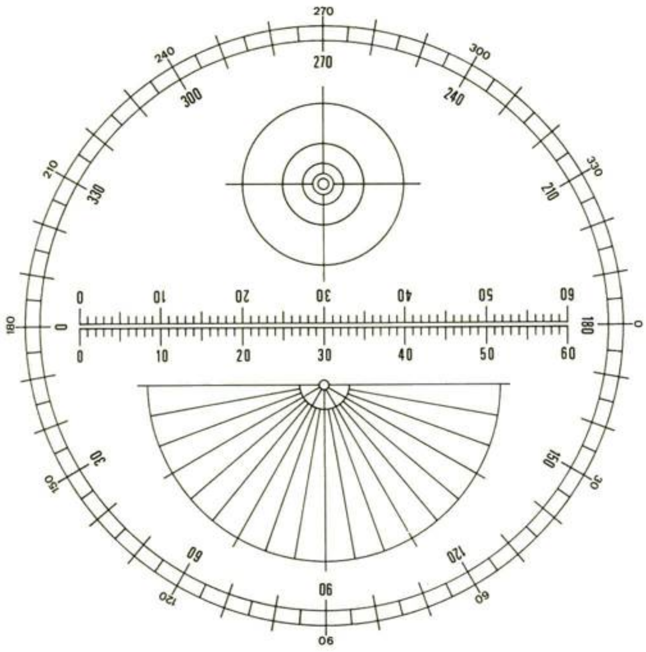

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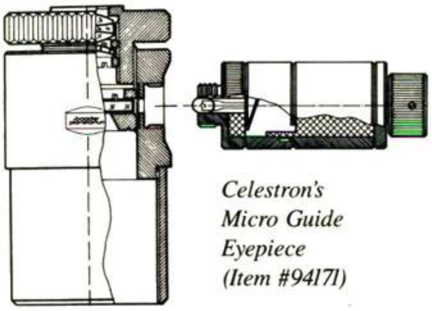

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lute statement than this statement about absolutes? Yet our imperfect human minds are quite capable of "knowing" this statement.

Before continuing his reflections on religion, Stahl might usefully reflect on another unquantifiable, undissectible thing: logic. — *Stephen Cox, La Jolla, California*

The Woes of Poor Telescopes

Forrest Bently's letter in the January 1990 issue cries out for a reply. He says that if it were not for the "small, imperfect refractor" he had as a child, he "may not have grown up to love the science of astronomy." I am glad that Bently's interest in astronomy survived his small refractor, but his experience is atypical.

As an astronomy columnist for a local newspaper, I have received scores of telephone calls from people complaining that they have difficulty finding anything with their small refractors. They complain that even if they do find an object the refractor's wobbly mount prevents them from keeping it in the field of view.

A pair of 50mm binoculars is a much better choice for beginning skywatchers. Most brands are well made, and they are often less expensive than cheap refractors. Besides, most objects visible in refractors — lunar craters, Milky Way starfields, the Galilean satellites of Jupiter — are also visible in binoculars.

If Bently had to field one of the many heart-wrenching calls I get each year after the holidays from frustrated adults and disappointed children, I think his opinion would change. — *Tom Burns, Columbus, Ohio*

Corrections

A word was omitted from the end of the last paragraph on page 22 of "The Fiery Fate of the Solar System" (April 1990). The word was "greenhouse."

In our May 1990 issue four photos were incorrectly placed due to a printer's error. The two photos of the Orion shell on page 10 of AstroNews were inverted and switched left for right. The two photos on page 27 of "The Coolest Stars" were also switched. □

ASTRONOMY welcomes comments, suggestions, and additional information on articles and astronomy in general. Send your letters to: ASTRONOMY Letters, P.O. Box 1612, Waukesha, WI 53187. Letters may be edited for length and clarity.

WHAT'S IN A NAME?

by Deborah Byrd
Creator of the Star Date radio program and regular ASTRONOMY columnist

I'm someone who doesn't like to name things. After having difficulty naming my share of dogs, cats, fish, and other small animals, the necessity of naming my first child came as a shock. But when I was a child myself, I recall looking up my name in a book, searching for some secret to my true identity. How chagrined I was to discover that my name means "industrious."

Will extrasolar planets, like some asteroids, receive silly, arrogant, or otherwise inappropriate names?

So the imminent discovery of planets in other solar systems makes me nervous. That these planets will be discovered seems certain. The evidence that they exist is mounting and the word is out among astronomers that a great breakthrough of the 1990s will be finding the first of these worlds. In conversations with astronomers who hunt "extrasolar" planets, it has dawned on me that when we find them we will name them. But frankly, I wish we didn't have to.

It's not that I object to naming things in the sky. The planets in our solar system, named for ancient gods, are like old friends in part because they have names. Likewise, the names of the stars, which stem largely from a time when people believed Earth lay at the center of the universe, enhance their tremendous appeal.

How *do* objects in space get their names? The bright planets were named too long ago for anyone to remember how, and each star name has a long cultural history. In more modern times, however, celestial objects have been named by their discoverers. The planets Uranus, Neptune, and Pluto received names from classical mythology. The asteroids, most of which orbit between Mars and Jupiter, also absorbed many mythological names, but eventually those names began to run out. Thus we now have asteroids named for astronomers' wives, plants, social clubs, and even an electronic calculator (1625 The NORC). Nowadays, asteroids are frequently named for living astronomers, often those working in the field of minor planets.

In this century the International Astronomical Union assumed the right to approve the official names for celestial objects, and just in time, too. In the past couple of decades spacecraft have scrutinized all the planets in our solar system except Pluto. Committees of astronomers under the auspices of the IAU have given names from the arts, literature, science, and history to huge numbers of their surface features.

This naming of everything nameable strikes me as overly enthusiastic. Still, we on Earth seem to be the only beings in this solar system, so why not? Besides, exciting names add to the popular appeal of a new discovery, perhaps thereby edging us closer to visiting some of them someday.

On the other hand, the naming of extrasolar planets makes me uncomfortable for two reasons. First, there's a strong possibility that in the decades ahead we will find a lot of them, and what method of naming them can be long sustained? Will extrasolar planets, like some asteroids, receive silly, arrogant, or otherwise inappropriate names?

More importantly, we know that these distant worlds don't belong to us, so by what right do we impose names from our cultures, or worse yet, names of our astronomers?

"But we have to call them *something!*" you will rightly say.

How true. And I'd be the first to want to call them something romantic, to add to their appeal. How about numbering them in order of discovery, so that the first planet discovered around Vega would be called Vega 1, the second Vega 2, and so on. With that system, at least, the name would carry some information about the planet. Vega 1 would probably be the largest, or at least the brightest, planet in that system.

Maybe someone else has a better idea. I wish only that before we call them anything, we would pause to consider carefully. There are billions of stars in our Galaxy, and perhaps millions of other solar systems. The planets in these systems have their own inherent dignity. Let's respect that.

And who knows? Some of them may have their own names already. □

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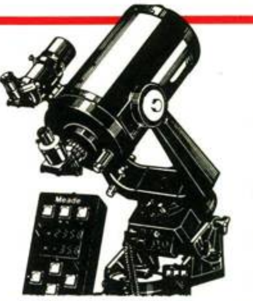

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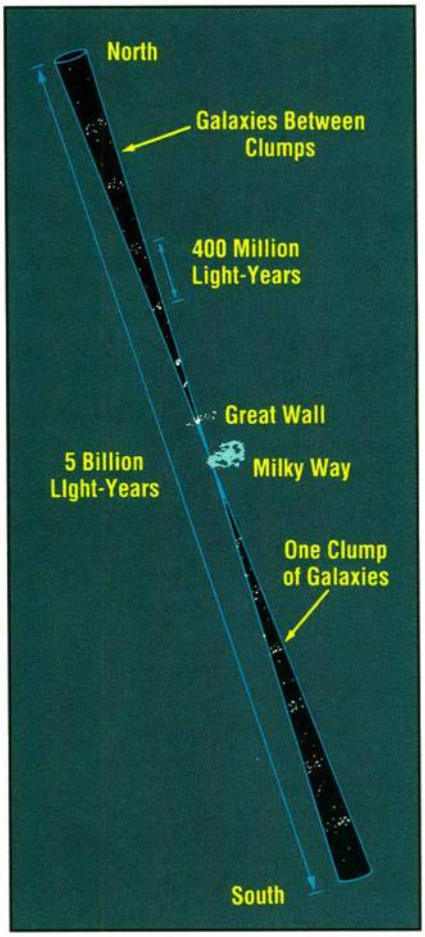
SKY SURVEYS REVEAL REGULARLY SPACED GALAXIES

Astronomers probing deeply in opposite directions of the sky have found about a dozen evenly spaced clumps of galaxies, each separated by vast volumes of space containing relatively few galaxies. The astronomers suspect that the clumps may be parts of a procession of walls of galaxies. If further observations support that suspicion, the universe may turn out to have far more structure on large scales than astronomers had thought likely, and that structure may have a regularity that would be difficult to explain with mainstream cosmological theories.

The findings are the culmination of over seven years of work by two independent groups of astronomers in the United States and Great Britain. David Koo of the University of California at Santa Cruz, Alexander Szalay of Johns Hopkins University, and Richard Kron and Jeffrey Munn of the University of Chicago began surveying the north galactic pole in the constellation Coma Berenices in the early 1980s from Kitt Peak National Observatory in Arizona. They surveyed all the normal galaxies in a region of the sky only slightly larger than the Full Moon. Meanwhile, British astronomers Thomas Broadhurst and Richard Ellis of the University of Durham undertook a similar survey of the south galactic pole, located south of the star Beta Ceti, from the Anglo-Australian Observatory in Australia. Their field covered half the angular size of the northern field.

Last year the astronomers teamed up to share their data in an effort to determine if the structure they were seeing was real. Several hundred galaxies in the two narrow observing cones were plotted according to their sky position and distance (derived from the redshifts of their spectral lines). The cones probed 2.5 billion to 5 billion light-years into the universe — deeper than most recent galaxy surveys.

The astronomers discovered that galaxies were clumped together at consistent intervals toward both the north and south galactic poles. The American group found six clumps within their survey region, and the British group found seven. Depending on the expansion rate of the universe, the clumps are between 400 million and 800 million light-years apart. Moreover, each clump seems to contain about the same density of galaxies.



CLUMPS OF GALAXIES were seen at regular intervals over a distance of 5 billion light-years by astronomers looking in opposite directions in the sky.

"We may be hitting several walls of galaxies, perhaps some of them even greater than the 'Great Wall,'" said Koo, referring to a structure some 200 to 400 million light-years away that emerged in a previous galaxy survey conducted by John Huchra and Margaret Geller of the Harvard-Smithsonian Center for Astrophysics (see "A Cross Section of the Universe," November 1989). In light of this new structure, the name "Great Wall" might be a premature appellation. "We may be seeing a *series* of Great Walls," said Koo.

The survey also took into account our galaxy's location with respect to the clumps. It turns out the Milky Way sits between two walls of galaxies. "But we're not right in the middle of the interval," said Koo. "We're sort of off to one side, about two-thirds of the way from the Great Wall on the north side and one third of the way from a wall on the south side."

Of all the results of this survey, by far the most disturbing is the regular spacing of galaxies. "People are having a very hard time with that," said Koo.

Over the past decade galaxy surveys have revealed larger and larger structures — filaments and walls of galaxies as well as vast voids. Some of these structures are larger than the surveys themselves and simply run off the map. But nowhere does the structure exhibit the kind of regularity seen in these two recent surveys. On the largest scales, says Koo, this structure may be like a honeycomb.

As intriguing as it is to speculate, Koo cautions against drawing conclusions about the way galaxies are distributed throughout the universe based on their survey. "It's possible we were just very, very lucky or that a statistical fluke at some level has produced this very periodic structure," said Koo. "If similar patterns appear elsewhere, however, theorists will have a lot of hard work to figure out how the universe could generate bubbles or shells or honeycombs of galaxies and imprint them on such large scales."

THE PECULIAR PULSAR THAT WASN'T

Hidden deep within the debris of supernova 1987A an exotic pulsar spins furiously on its axis. That, at least, is what astronomers think was left behind by the supernova explosion. The first direct observational "proof" of the pulsar, however, was spurious. A series of regular pulses that were thought to be emanating from the supernova have turned out to be electrical interference from a television camera used on the telescope. John Middleditch, one of the team of astronomers who detected the signal in January 1989, announced the mistake at the February 1990 meeting of the American Association for the Advancement of Science in New Orleans.

When the pulsed signal was detected in January 1989 astronomers were astonished by its implications. (See "The Peculiar Pulsar in Supernova

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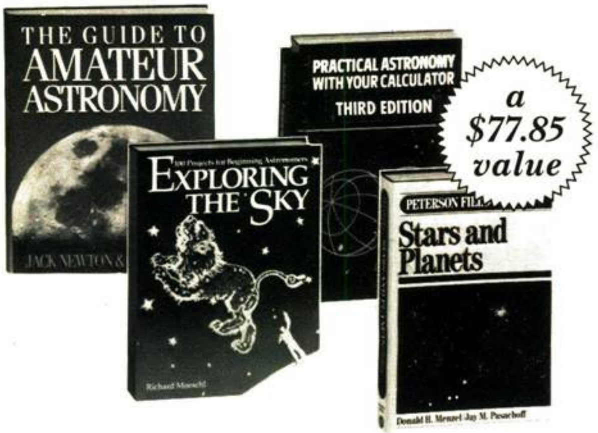
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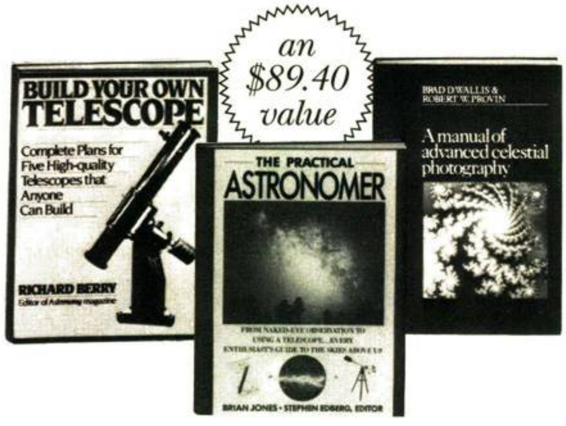
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1987A," September 1989.) Not only would this have been the fastest rotating pulsar ever seen — spinning on its axis almost two thousand times each second — it was near the maximum speed a condensed ball of neutrons could rotate without flying apart. These and other conundrums tantalized astronomers and physicists, all of whom wanted to understand this extraordinary object.

Unfortunately, since the initial detection with the 4-meter telescope at Cerro Tololo, no subsequent pulses had been detected despite repeated attempts. Although discomforting, this lack of confirming evidence could have meant nothing more than that in January the pulsar was shining through a small hole in the clumpy debris from the supernova explosion, while afterward it was hidden behind the debris. The initial observation convinced most astronomers of the pulsar's authenticity, in part because observations of a globular cluster on the same night with the same telescope showed no periodic signal.

That's where the matter stood until this January. During an observing run at Las Campanas Observatory in Chile, the research team detected a strong, periodic signal coming from supernova 1987A. This time, however, the frequency of the signal implied a pulsar spinning nearly eight thousand times a second, exactly four times faster than the original signal and far too fast for any even remotely plausible pulsar. The signal had all the earmarks of electrical interference. A camera used to transmit images from the telescope to the control room was the culprit.

The bad news was confirmed during an observing run at Cerro Tololo in early February. While looking at the pulsar in the Crab Nebula a signal similar to the one seen in January 1989 appeared in the data. Because the Crab pulsar is much different from the one they believed they saw in supernova 1987A, the researchers knew the original observations had been erroneous.

At this stage no one knows why the interference appeared only three times. But the reason the signal vanished when they observed the globular cluster later that night in January 1989 is clear: The researchers had turned off the extremely sensitive television camera to protect it from the encroaching dawn.

The search for the elusive pulsar in supernova 1987A continues. And even if it turns out to be less exotic than the one they thought was there, astronomers remain excited about seeing a young pulsar for the first time.

A SOLAR PROMINENCE viewed against the background of the much hotter corona, from which it condensed. The prominence is supported by a magnetic field (superimposed line). Photo courtesy of M. J. Martres of the Paris Observatory, Section de Meudon, France.

COOKING UP SOLAR PROMINENCES

Solar prominences, tongues of gas seen projecting from the solar surface into the chromosphere, have long fascinated astronomers, but explaining what prominences are is a far easier task than explaining how they form.

Although most astronomers agree that prominences condense from gas in the rarefied million-degree corona it is not clear how this process occurs. Some solar physicists have proposed that magnetic-field activity cools the corona to less than one-hundredth its normal temperature, allowing the gas to condense into prominences. The problem with this explanation, however, is that gravity would cause much of the cooled, dense gas to drain back to the solar surface before a prominence could form.

Two researchers may have theorized their way out of this dilemma. Spiro K. Antiochos of the Naval Research Laboratory in Washington, D.C., and James A. Klimchuk of Stanford University suggest that the corona is magnetically heated by the "footings" of the prominences in the Sun's surface. The theory was presented at January's meeting of the American Astronomical Society in Arlington, Virginia.

According to their computer model, the initial heating causes gas to surge up from the solar surface into the corona. The added gas increases the corona's density, thus causing it to emit more radiation. The photons emitted actually help cool the coronal gas by carrying away energy, similar to the way hot objects radiate heat.

The cooled gas can now condense into a prominence. Meanwhile, increased magnetic heating at the lower level of the corona prevents the prominence gas from collapsing back to the surface but doesn't effect the temperature higher up.

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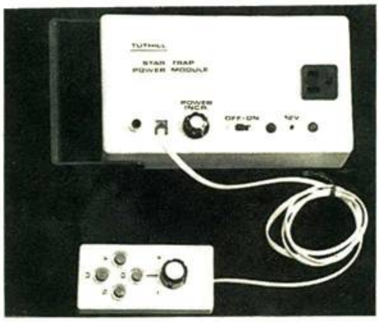

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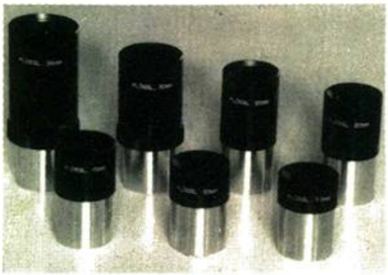

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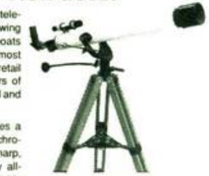

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Solar system observations are dramatically improved by Orion colored filters. For visual use, thread one into the barrel of any standard eyepiece. For planetary and lunar photography, Schmidt-Cassegrain owners can attach the filter to the eyepiece inside the tele-extender. Can also be threaded directly into a universal camera adapter.

Basic Set of 4 Filters .965"- Includes #80A Blue, #58 Green, #25 Red, #15 Yellow. #5510 **$29.95** (1.89)

Basic Set of 4 Filters 1.25"- Includes #80A Blue, #58 Green, #25 Red, #15 Yellow. #5514 **$39.95** (2.19)

Expansion Set of 4 Filters 1.25"- Includes #21 Orange, #47 Violet, #11 Yellow-Green, #82A Very Pale Blue. #5516 **$39.95** (2.19)

Deluxe Set of 8 Filters 1.25"- Includes all the filters in our basic and expansion filter sets. #5517 **$74.95** (2.79)

Individual 1.25" Filters- #80A Blue (#11040), #58 Green (#5540), #25 Red (#5536), #15 Yellow (#5532), #21 Orange (#5534), #47 Violet (#5538), #11 Light Yellow-Green (#5530), #82A Very Pale Blue (#5544) **$11.95 ea.** (.99)

Moon Filters

Cuts 87% of the light from the Moon. Reduces glare by uniformly reducing light transmitted over the entire spectrum.

.965" #5664 **$14.95** (1.89)

1.25" #5662 **$14.95** (1.89)

Variable Polarizing Filter Set

Adjustably reduces the light transmission of visual images, so you can see more detail. Also ideal for cutting glare from water, window glass during terrestrial observation.

.965" #5558 **$19.95** (1.89) 1.25" #5560 **$24.95** (1.89)

Popular Observer's Chairs

Make observing more comfortable and enjoyable with one of these great chairs.

Standard Model-
Has adjustable-height center column and padded vinyl seat. Folds for easy storage. #5935 **$39.95** (3.69)

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Is much heavier-duty, built for professional musicians. Extra thick padding, wide footprint. Adjustable, disassembles for storage. #5934 **$88** (5.65)

Orion® 2" Multi-Coated Eyepieces

Excellent wide-field eyepieces.

32mm Erfle 2" Eyepiece #8492 **$99** (2.59)

50mm Plössl 2" Eyepiece-
Brightest, widest field. Preferred for faint celestial phenomena. #8490 **$79** (2.59)

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Achromatic, fully coated 2-element lens system with finest machined aluminum construction. Ideal for reflector and refractor telescopes.

2x 1.25" Barlow Lens #8744 **$39.95** (1.89)

2x .965" Barlow Lens #8742 **$27.95** (1.89)

Orion® VariPower™ 2-3x Multi-Coated Barlow Lens

Our best barlow offers significant improvement over other models we've seen. The magnification is adjusted by sliding the internal lens cell along a calibrated scale (you don't have to poke a finger or pencil inside to do this). Fully Multi-Coated optics provide excellent sharpness, contrast and brightness. 1.25" diameter.

#8748 **$69.95** (2.19)

Orion® 3-element Fully Multi-Coated Barlow Lens

Fully Multi-Coated 3-Element Barlow lens provides superior imaging with precise color correction at three wavelengths. For maximum light transmission and highest contrast, we have used the finest quality multi-coating on each air to glass surface. 1.25" diameter

#8750 **$59.95** (2.19)

Orion® Deluxe Fully-Baffled Multi-Coated Barlow Lens

Fully internally opaqued and baffled to block stray light for noticeably higher contrast. Large 27mm multi-coated 2-element lens provides 2x magnification with any 1.25" eyepiece.

#8746 **$49.95** (2.09)

Orion® Dew Zapper

Orion's Dew Zapper is a sure-fire cure for dew problems on your 8" or 10" Celestron or Meade Schmidt-Cassegrain telescope. Dew Zapper gently replaces lost heat, bringing the corrector plate temperature slightly above air temperature.

8" Dew Zappers- fit all Meade & Celestron 8" Schmidt-Cassegrains

DC Model #3503 **$34.95** (1.79)

AC Model #3504 **$34.95** (1.79)

10" Dew Zappers- fit all Meade 10" Schmidt-Cassegrains

DC Model #3506 **$39.95** (1.79)

AC Model #3508 **$39.95** (1.79)

Dew Remover Gun

Moisture that interferes with viewing dissipates quickly with this 12V DC, 156 watt warm air gun. Has 4-1/2' cord.

#5601 **$17.95** (2.09)

NiteWriter Pen

Incredible pen with built-in red light! With extra refill, batteries.

#5709 **$8.95** (1.89)

Starlite Red LED Flashlight

The Starlite is the only adjustable-brightness night-vision red flashlight. Lifetime solid-state LED can't burn out. Extra efficient electronic circuit for long battery life. Uses one 9-volt battery (not included).

#5714 **$24.95** (1.89)

Astronomer's Flashlight

Indispensable and indestructible. Has special night-vision red filter and a diffusion lens for even illumination. An essential addition to your astronomy accessories. Requires 2 D-cell batteries (not included).

#5701 **$8.95** (1.89)

Rechargeable Batteries

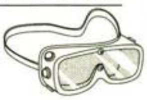
5.0 Amp Hour Porta Pac
Perfect for Meade LX6, LX5, and LX3; and Celestron Powerstar 8, and SPC-8 (with adapter). Also suitable for all drive correctors and motor drives. Battery is encased in high-impact polystyrene. Built-in handle. Wt. 5 lbs.

#2352 **$69 ea.** (4.56)

12 Amp Hour Porta Pac
Ideal for operating your telescope plus higher power-consuming accessories such as an Orion Dew Zapper. Battery is encased in high-impact polystyrene. Carrying case of Cordura nylon with shoulder strap and handle. Wt. 10 lbs.

#2354 **$99 ea.** (6.23)

Astrogoggles



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For Meade 8" 2080 #5150 **$74.95** (3.46)

For Celestron 8" C-8 #5149 **$79.95** (3.46)

For Meade 10" 2120 #5152 **$84.95** (3.46)

Orion® Premium Off-Axis Guider

Use with any 1.25" Illuminated Reticle Eyepiece. For Meade and Celestron Schmidt-Cassegrains.

#5144 **$59.95** (1.89)

Universal Camera Adapters

Standard Universal Camera Adapters
Combination Eyepiece Projection Tube and Prime Focus Adapter for refractors and reflectors with 1.25" eyepiece holders. Use with T-Ring (sold separately) to match your 35mm camera.

.965" #5268 **$29.95** (1.89)

1.25" #5264 **$34.95** (1.89)

Variable Power Camera Adapter
Unique sliding barrel design allows variable projection distances during eyepiece projection photography, eliminating the need to change eyepieces when magnification changes are required.

#5262 **$44.95** (1.89)

Orion® T-Adapter

For prime focus photography. Use with T-ring to match your 35mm camera. For Meade, Celestron 8", 10" SC.

#5116 **$27.95** (1.89)

Orion® Tele-Extenders

For high powered photography with your Meade, Celestron 8", 10" Schmidt-Cassegrain

Standard Tele-Extender
Use this Tele-Extender in conjunction with an eyepiece. Attaches to visual back of Meade or Celestron Schmidt-Cassegrain telescopes, and to 35mm camera with T-ring, sold separately. #5125 **$27.95** (1.89)

Variable Tele-Extender
Uses an adjustable extension tube, allowing magnification to be changed without switching eyepieces. Thumbscrews lock extension tube securely in place. Attaches to 35mm camera with T-ring, sold separately. #5127 **$39.95** (1.89)

Orion® Tele Compressor

Get four times the brightness and 1/2 the exposure time. Doubles your field of view for astrophotography. For Meade, Celestron 8", 10" SC. #5141 **$34.95** (1.89)

Orion® 2x Rich Field Adapter

Get four times brighter image and twice the field of view. For Meade, Celestron 8", 10" Schmidt-Cassegrains.

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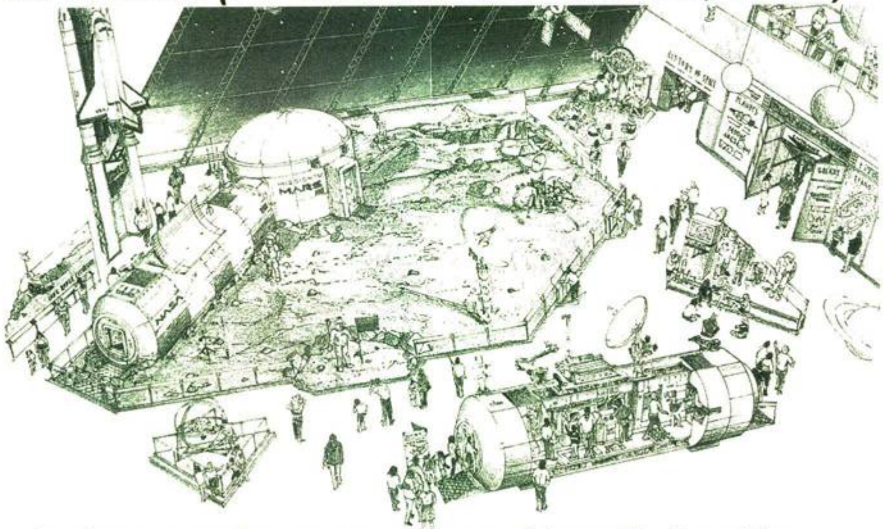
Space News

TO MARS! (BY WAY OF COLUMBUS, OHIO)



Americans across the country can "travel" to Mars next year, thanks to an elaborate new interactive exhibit being developed at the Center of Science and Industry in Columbus, Ohio. The center's $1.6 million "Mission to Mars" exhibit, scheduled to open in January 1991, will allow visitors to chart their own simulated journey to the Red Planet.

The exhibit will have three major components: a manned Mars outpost, a simulated Martian landscape, and a space station. A network of computers linked to laser videodisks will orchestrate a mix of sound, graphics, and animation to simulate the trip to Mars and to give a taste of what scientists at stations on the Red Planet might do as part of their research. Participants can organize an expedition to recover the *Viking I* spacecraft, gather soil samples, predict Martian weather, and set up food production and testing facilities.

Teachers will be able to reserve time on the exhibit for their classes. Students can be assigned different roles, such as determining the optimum time to leave, calculating orbits, and identifying the season on Mars by using constellations. Students play the roles of scientists and astronauts. They, like their real-life counterparts, will try to answer the question whether we can live on Mars. The simulated expedition takes place in the year 2036. The simulation assumes a Mars-orbiting space station, Ares I, so participants can take on roles that include scientists from both the surface expedition and the Mars orbiter.

"Space and space exploration are extremely powerful topics with kids," said Roy L. Shafer, center president and chief executive officer. "We think it's an exciting way to motivate kids to want to learn more about science and math." The exhibit is geared toward fourth, fifth, and sixth graders, although according to "Mission to Mars" exhibit developer Bill Buckingham, "anyone can learn something from it."

The heart of the simulation is a series of twenty-eight Macintosh computers that link visitors with videos that take the traveler through space and onto the Martian landscape. Funding was supplied by the National Science Foundation, Apple Computer, Inc., the Battelle Memorial Institute in Columbus, other science centers, and in-kind donations from the Center and Seattle's Pacific Science Center.

Although the display does not officially open until 1991, Buckingham said many of the modules will be completed and available for viewing by September. After its initial run in Columbus, the exhibit will embark on a nationwide tour of science centers in Seattle, Los Angeles, Portland, Fort Worth, Orlando, Philadelphia, Indianapolis, Charlotte, Boston, St. Paul, Chicago, and Atlanta. — *Bob Gibson*

Amateur News

PENNSYLVANIA LIGHT POLLUTION VICTORY

"Score another success in the battle against light pollution," said Robert Mohr of the Lehigh Valley Amateur Astronomical Society in Allentown, Pennsylvania. After campaigning for several months, the group's Light Pollution Abatement Committee convinced the local board of supervisors to enact a law severely limiting light pollution in the Berks County township of Windsor.

"The law is one of the most restrictive in the nation," said Mohr. "Windsor Township Ordinance 42, as it is known, requires that businesses turn off outdoor signs within thirty minutes of closing, or at 10 p.m. local time, whichever is later. That will significantly help local observers."

The ordinance states that the "proliferation of certain types of outdoor light fixtures is undesirable, since said light fixtures waste significant amounts of electricity, can produce glare often hazardous to drivers on Township and Commonwealth roads, may emit harmful ultraviolet radiation, and produce light pollution."

The ordinance goes on to say that all lights installed in the future must be properly shielded or filtered, and all fixtures used for lighting streets and parking lots must contain low-pressure sodium vapor lamps or filtered mercury vapor lights. Penalties for violating the ordinance include a $1,000 fine.

"We couldn't be happier," said Mohr. "We're currently working with a number of other local townships to see

HOW FAINT CAN TELESCOPES GO?

One of the perennial debates in amateur astronomy centers on the limiting magnitudes of telescopes. The question has practical significance for variable star observers and skywatchers who want to recover and estimate the brightnesses of comets and asteroids. The technique also allows astronomers to systematically check the progress of light pollution as it raises the limiting magnitudes at certain sites. But due to the many variables involved with accurately estimating limiting magnitudes, the answer to "what's the faintest star your telescope can show you" has never been adequately answered — until now.

Bradley E. Schaefer, an astronomer at NASA's Goddard Space Flight Center, reported on limiting magnitudes in the February 1990 issue of the *Publications* of the Astronomical Society of the Pacific. In his set of theoretical algorithms, Schaefer takes into account the sensitivity of an observer's eye, the transmission of the atmosphere and the telescope, the brightness of the sky, the color of the star being observed, the age of the observer, the aperture, and the magnification. These factors together produce an equation that yields values accurate to within half a magnitude.

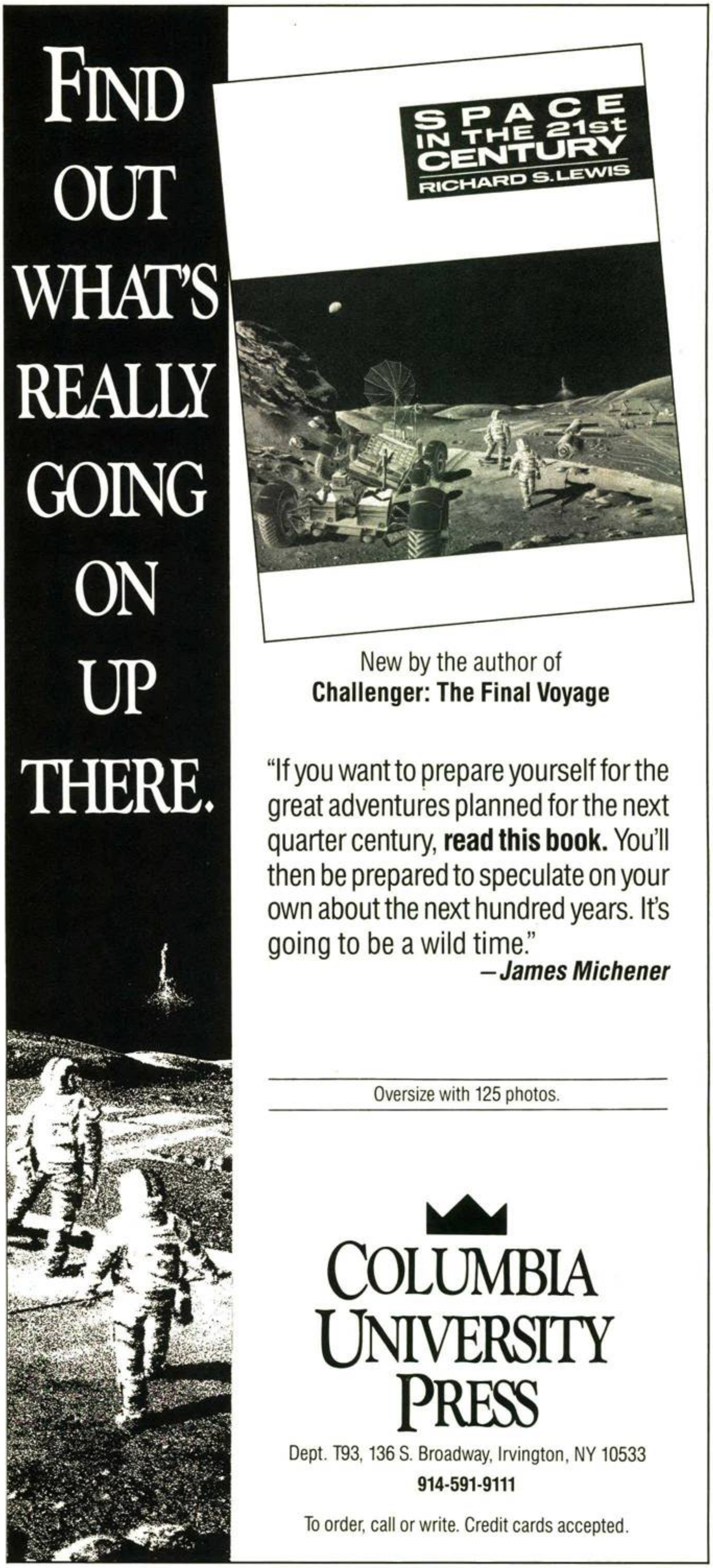
Schaefer's equation predicts that a 5-inch telescope can show stars down to 12.5 magnitude at 30x. However, if the magnification is boosted to 200x, the same telescope shows stars fully one magnitude fainter. A 10-inch telescope at 100x shows stars as faint as magnitude 13.3; at 400x it reveals stars fainter than 15th magnitude.

The most unusual result of Schaefer's study is an analysis of the 1985 sighting of Comet Halley by amateur astronomer Stephen James O'Meara when the comet glowed feebly at magnitude 19.6. While many observers are skeptical of such a feat, Schaefer feels his analysis supports O'Meara's claim that he was the first to see Halley on its

METEOR SOCIETY FORMS

Encouraged by recent interest in meteorites, a small group of observers in England and Canada have formed an organization devoted to meteorite collecting. The Society of Meteoritophiles will promote meteorite and tektite collecting and create a greater awareness of the subject. To these ends the society will publish a journal called *Impact!*, through which members may exchange views and keep informed of what's happening in the field of meteoritics.

Persons interested in membership information should write to the Society of Meteoritophiles, Philip M. Bagnall, 9 Airedale, Hadrian Lodge West, Wallsend, Tyne & Wear, England NE28 8TL; or to Chris E. Spratt, 314-2100 Granite Street, Victoria, British Columbia, Canada V8S 3G7. □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LUMICON FILTERS HELP FIND A COMET

ASTROPHOTO OF THE MONTH

Comet Aarseth-Brewington 1989a1, discovered by Howard Brewington ***using a 48mm LUMICON Swan Band Comet Filter!*** "The filter doubled contrast, making the comet very easy to spot," said Mr. Brewington. His 60 second photo on hypered 2415 (8" f/1.5) shows a nice tail.

20mm NAGLER

Also new 12mm & 16mm NAGLERS TELE VUE™ EYEPIECES USE THE BEST!!

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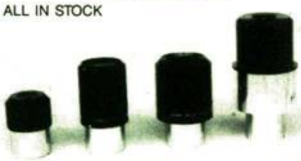

Oracle 3" f/7.4 Triplet Apochromat	**$750**
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Renaissance 4" f/5.5. Telescope	**$1450**
7.4, 10.4, 13, 17, 21, 26mm Plossl, 50°	**$89**
1.8X or 2.5X Tele Vue Barlow Lens	**$89**
32mm Plossl, widest true field in 1¼"	**$109**
55mm 2" Plossl, widest possible field	**$219**
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19mm Wide-Field, 1¼" eyepiece, 85°	**$145**
24mm Wide-Field, "superb," 65°	**$169**
32mm Wide-Field, 2" eyepiece, 65°	**$239**
40mm Wide-Field, "awesome," 65°	**$299**
4.8mm Nagler, 82° field	**$149**
7mm Nagler, 1¼" eyepiece, 82° field	**$189**
9mm Nagler, 82° field, "the best"	**$219**
11mm Nagler, 82° field, 1¼" or 2"	**$235**
13mm Nagler, 82° field, 1¼" or 2"	**$249**
12mm Nagler, Type II, 82°, 1¼"/2"	**$249**
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ADJUSTABLE PIGGYBACK MOUNT

The LUMICON adjustable piggyback mount is ideal for telescopes of 6-16" aperture. It permits **both** vertical and sideways adjustment for optical alignment. Also ideal to mount LUMICON 80mm SUPER-FINDER™, large telephoto lenses and small telescopes up to about 5 lbs.
LUMICON Adjust. Piggyback Mount .. **$54**
Specify telescope size: 6", 8", 10", 11", 14", 16"

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Specify Lens Size	**H-Alpha**	**(MV)**
46, 48, 49mm	**$47.00**	**$39.00**
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67, 72, 77mm	**$69.00**	**$59.00**
82mm	**$79.00**	**N/A**

Hypered 2415 film, 36 exp .. **$10.95, $3/$29**

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1.32"	**$29.95**	1.52"	**$34.50**	1.83"	**$39.50**
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4.25"	**$149.50**	4.00"	**$149.00**		

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90° star diagonals with 96% reflectivity enhanced aluminum mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

1¼" (1.32" mirror)	**$99.50**
2" (1.83" mirror)(see photo above)	**$159.00**

LUMICON FILTERS STOP LIGHT POLLUTION

UHC Filter™

ULTRA HIGH CONTRAST

The **LUMICON UHC FILTER** is specially designed for visual astronomy in areas of severe light pollution or for viewing very faint nebulae at any location. **UHC** stands for **U**ltra **H**igh **C**ontrast and this filter is guaranteed to yield a higher visual contrast on planetary and emission nebulae than any other filter at any price. 24nm visible bandpass, 482-506nm. Transmission = 90-97%.

For optimum astronomy, use either the **LUMICON DEEP-SKY Filter or the LUMICON UHC Filter**

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Tom Kramer saw the Owl Nebula, M-97, for the first time using a LUMICON UHC Filter. He stated, *"I had never seen M-97. . . I attached the UHC Filter and tried again. M-97 was right there. I could not believe it! The UHC Filter should be standard equipment."*
Tom Kramer, Sayville, NY

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The **LUMICON DEEP-SKY FILTER** improves your view of **all** deep-sky objects including galaxies and comets. It removes natural and man-made light pollution and yields 3-6x contrast gain for nebulae and 1-3x contrast gain for clusters and galaxies. It is ideal for **both** visual use and B&W or color photography. This gentle filter yields the most natural view of any LPR filter available today. 90nm visible bandpass. 442-532nm. H-Alpha 656nm transmission = 85-95%. Visible transmission = 85-95%.

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**Premium filters are selected best of the lot and typically have 5-10% higher transmission. All Lumicon filters include individually measured transmission data.*

DEEP-SKY ASTROPHOTOGRAPHY

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U.S. Patent 4,473,636

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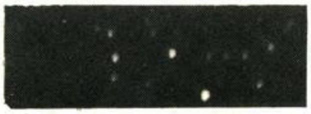

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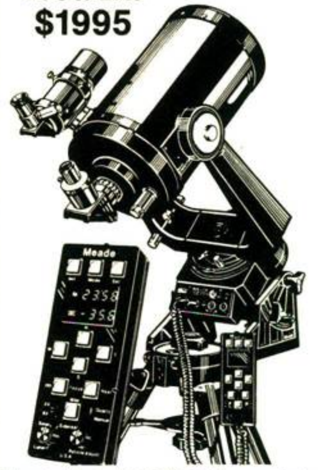

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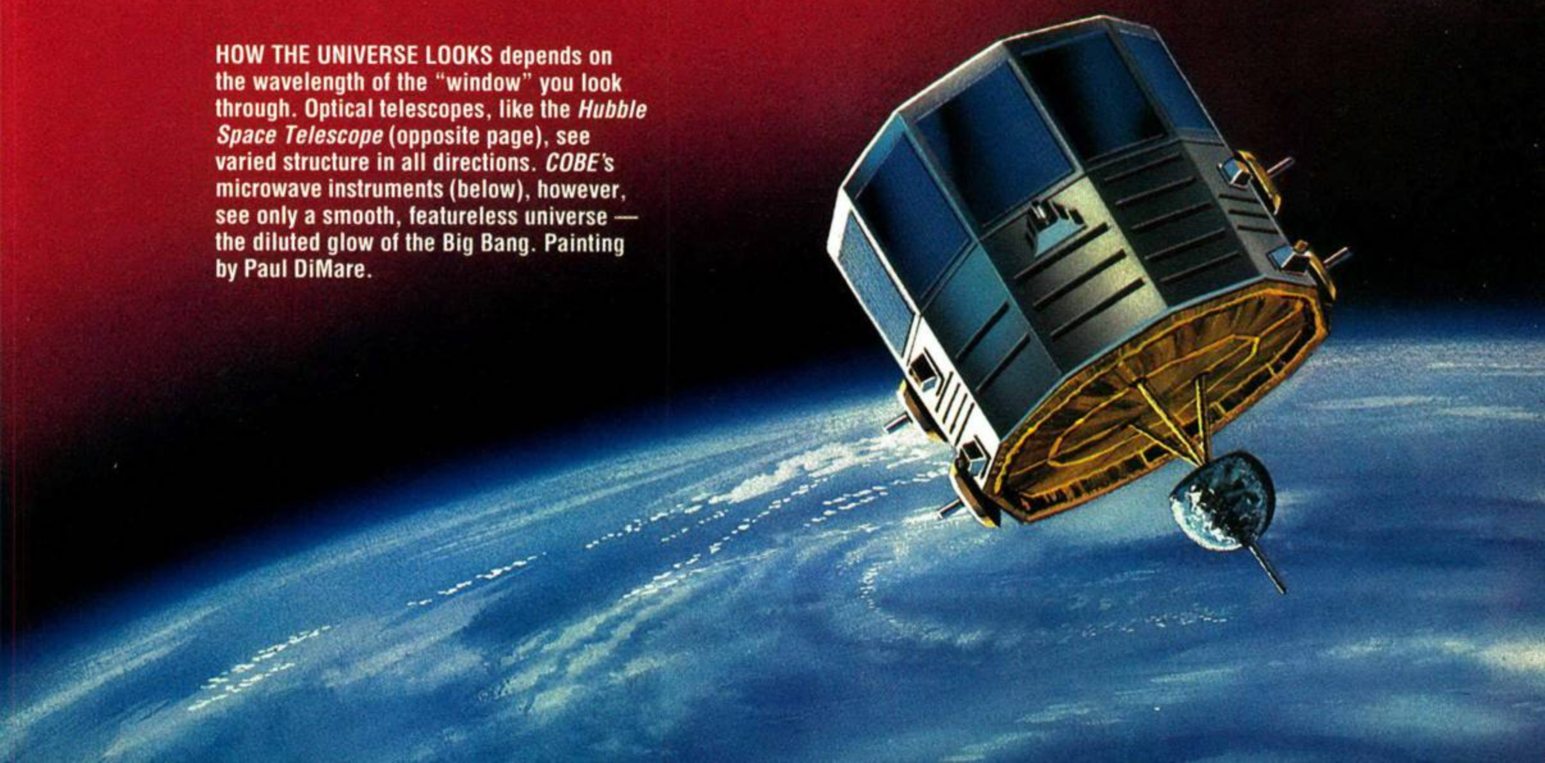
Too Smooth

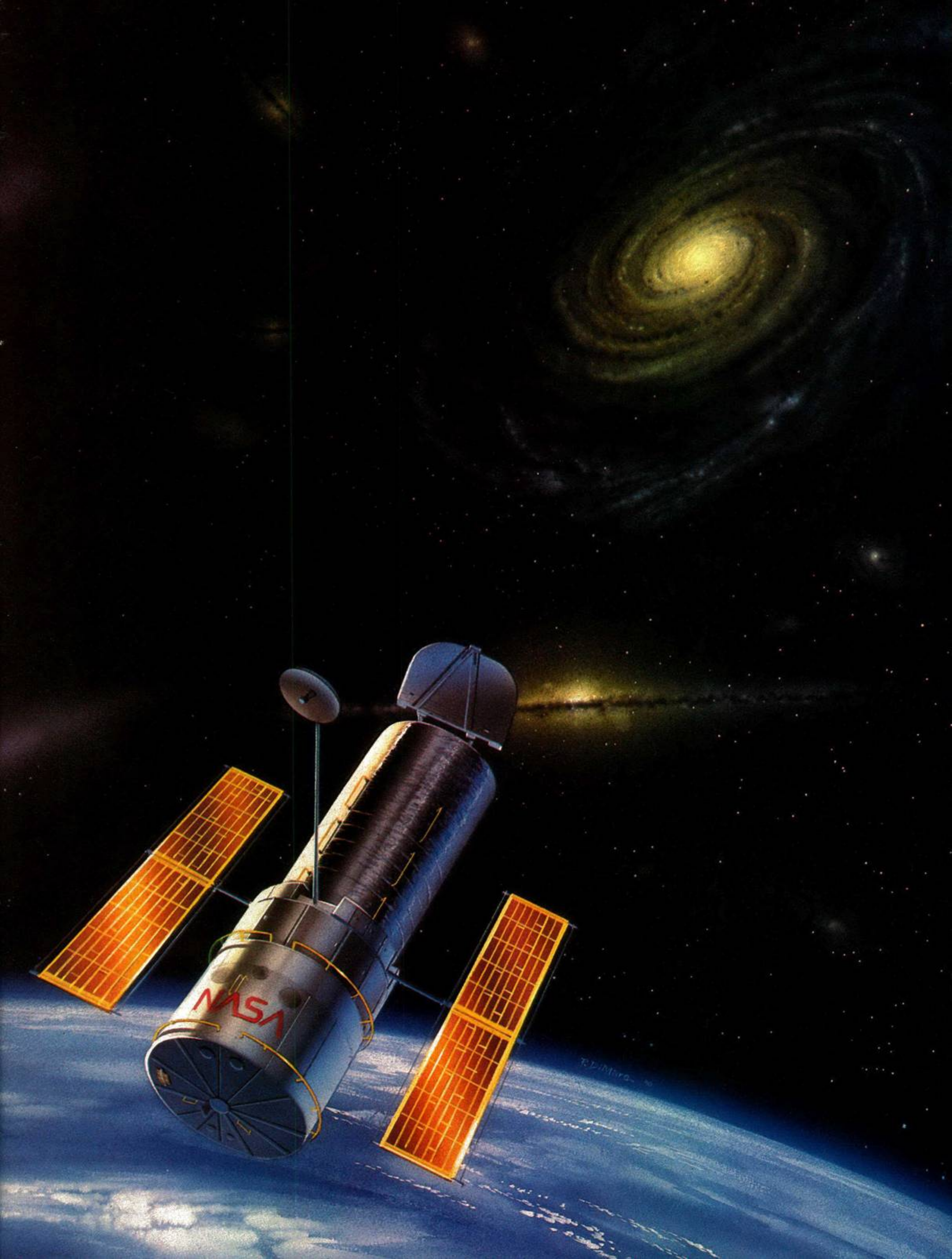
COBE's Perfect Universe

If the early universe was as uniform as recent observations from the Cosmic Background Explorer indicate it was, where did the galaxies come from?

by Jeff Kanipe

HOW THE UNIVERSE LOOKS depends on the wavelength of the "window" you look through. Optical telescopes, like the *Hubble Space Telescope* (opposite page), see varied structure in all directions. *COBE*'s microwave instruments (below), however, see only a smooth, featureless universe — the diluted glow of the Big Bang. Painting by Paul DiMare.

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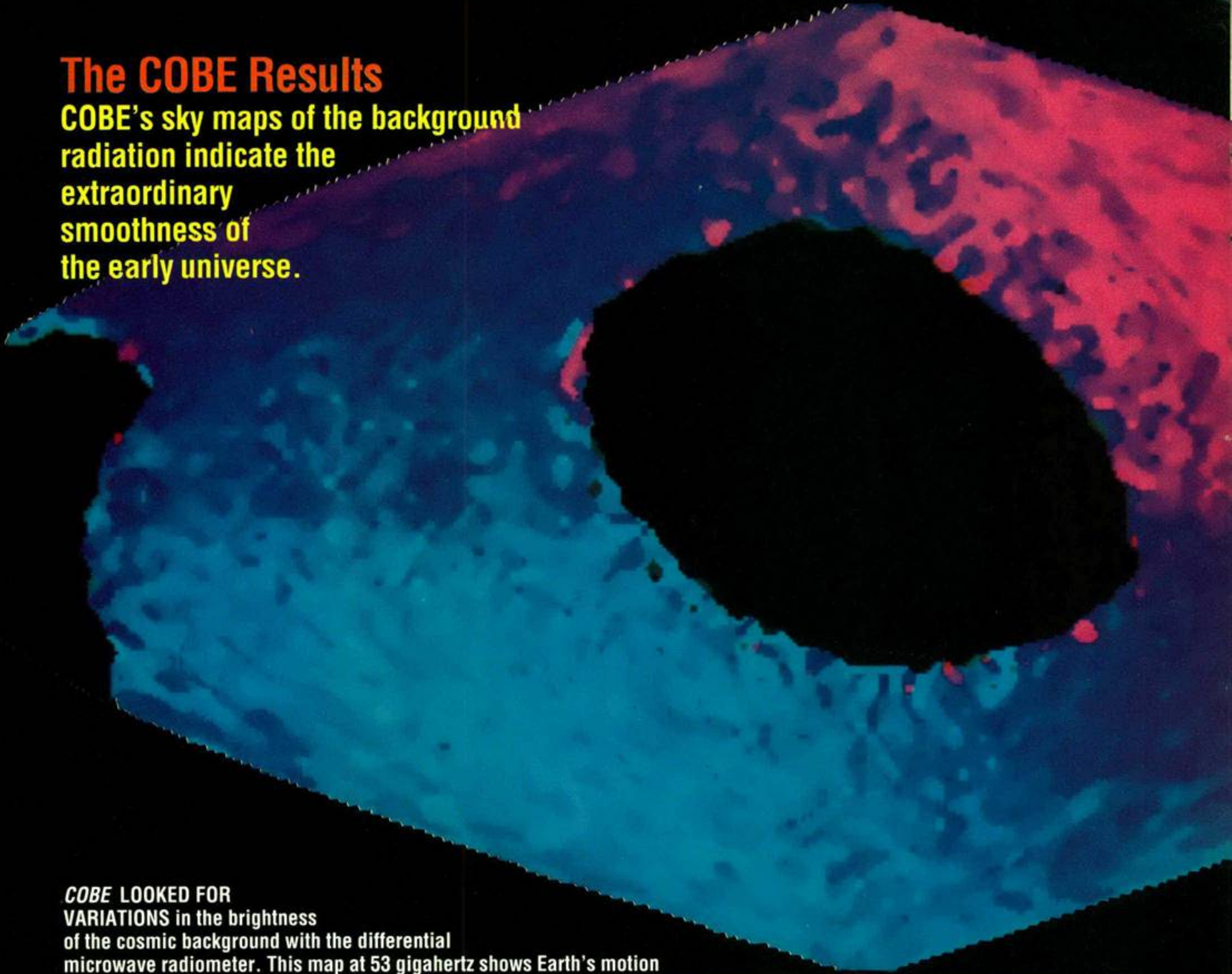
The COBE Results

COBE's sky maps of the background radiation indicate the extraordinary smoothness of the early universe.



***COBE* LOOKED FOR VARIATIONS** in the brightness of the cosmic background with the differential microwave radiometer. This map at 53 gigahertz shows Earth's motion relative to the background (pink indicates motion toward the radiation and blue is motion away from it). The black regions were not observed because the Sun (edges) and Earth (center) were in these locations when the map was made. Taking Earth's motion and the obscured zones into account, the background brightness is the same in all parts of the sky. The "curdled" features are areas of sky below *COBE*'s angular resolution that have not yet been fully mapped. NASA photo.

When the *Cosmic Background Explorer* first looked into deep space last December, it saw a perfect universe, one without features to give it shape or variation to give it diversity. To *COBE*'s eyes the afterglow of the Big Bang was a vast, smooth backdrop radiating everywhere at a temperature barely above absolute zero. The definitive measurements of this background radiation finally confirm what astronomers have long suspected about the universe. Many are already ranking *COBE*'s findings as among the most important cosmological achievements of the century.

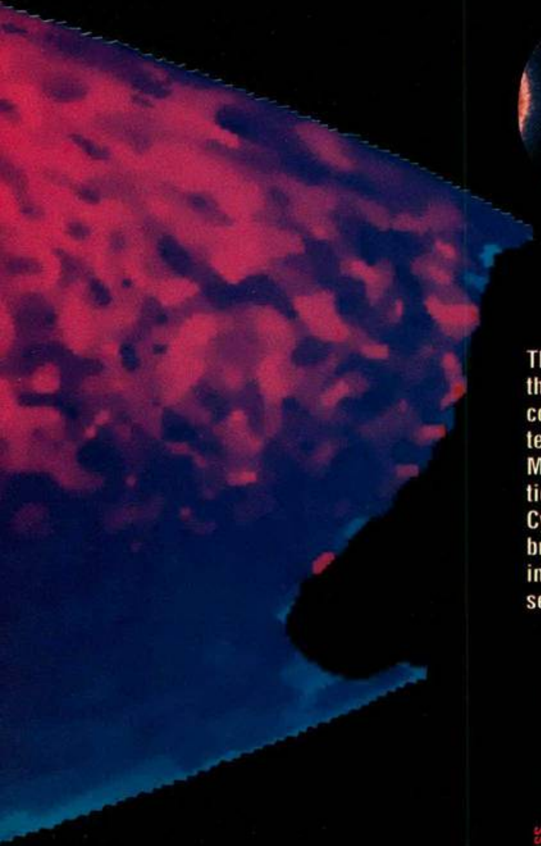
Since its launch on November 18, 1989, *COBE* has exceeded all expectations. The radiation from the Big Bang has had 15 billion years to expand and cool and is today remarkably feeble — about 100 million times fainter than the heat produced by a typical birthday candle. Nevertheless, in only nine minutes of sky observations *COBE* nailed down the microwave background temperature at 2.735 kelvins, with an uncertainty of only 0.06 kelvins. Moreover, *COBE* confirmed that this temperature is remarkably uniform, or isothermal, across the entire sky.

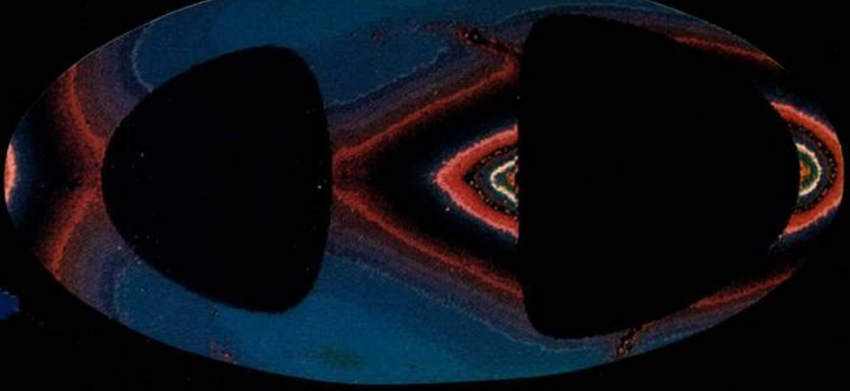
The task now facing astronomers in the wake of the *COBE* results is to explain how galaxies could have formed in such a serene universe. According to current galaxy formation theories, the smoothness of the early universe must have been stirred up in some way, perhaps by explosions of supermassive objects. These disturbances would have served as the seeds around which matter collapsed into galaxies. The energy released by these initial disturbances should be detectable today in the cosmic microwave background, but *COBE* didn't find any. Clearly, cosmologists are going to have to come up with a more elaborate way to make their galaxy formation theories fit the *COBE* observations.

What *COBE* Saw

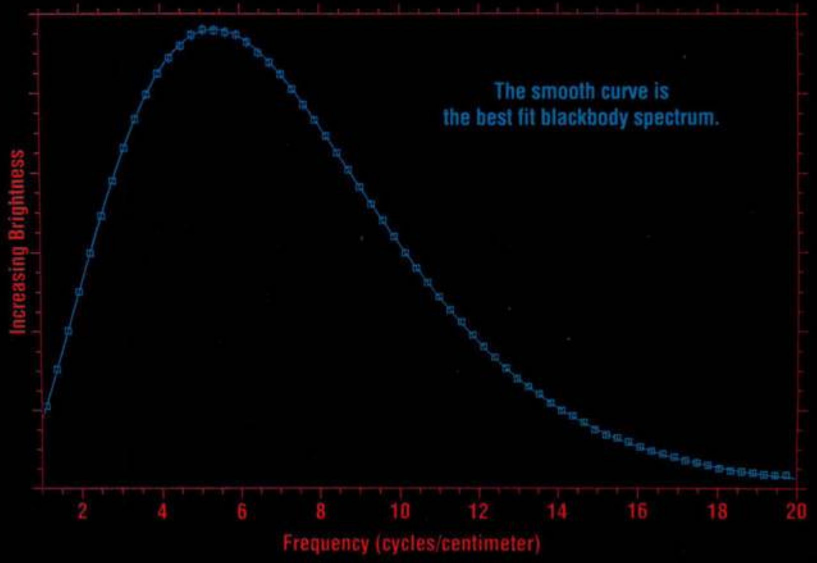
Without a doubt the most spectacular of the *COBE* results was the isothermal background spectrum, which was generated from data taken by *COBE*'s far infrared absolute spectrophotometer (FIRAS). According to John Mather, *COBE* project scientist and FIRAS principal investigator, the instrument "can look back and measure the intensity of the radiation one year after the Big Bang," which is farther back than any other instrument has ever measured.

Comprised of sixty-seven measurements across twenty different frequencies, the spectrum shows that





THE SEARCH FOR RADIATION from the first stars and galaxies was conducted by the diffuse infrared background experiment aboard *COBE*. The squatty, cone-shaped contour extending right to left through the center of the image is emission from interplanetary dust grains in the ecliptic plane. Emission from interstellar dust in the Milky Way is prominent in the ring-shaped feature, which is interrupted by the position of the Sun and Earth (right and left blank areas, respectively). The Milky Way in Cygnus is at top, and Carina is at bottom. The Large Magellanic Cloud is the small bright patch at bottom center. The "spots" throughout the map are individual stars in our Galaxy. Looking beyond these local structures, no significant features are seen. NASA photo.



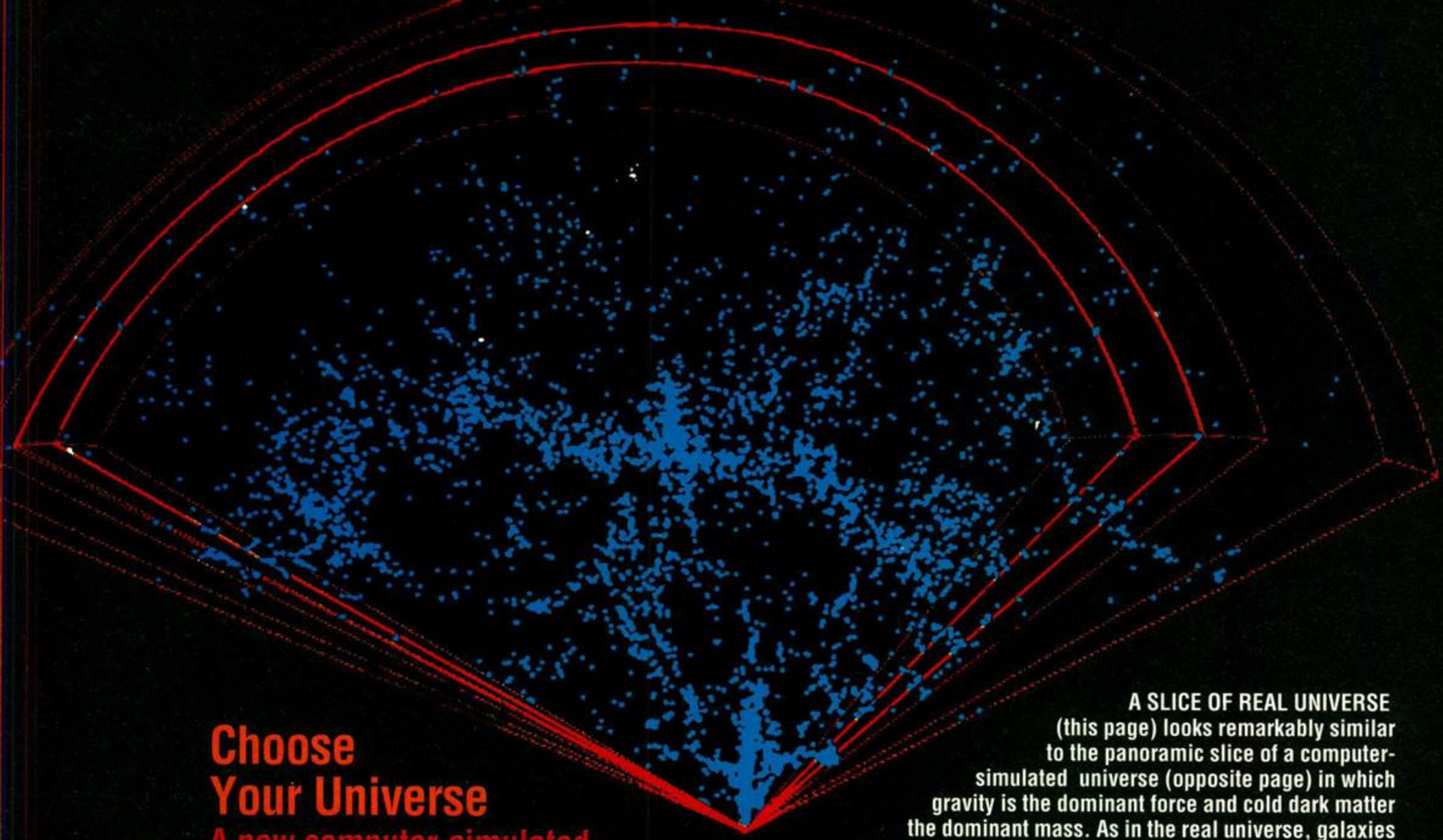
The smooth curve is the best fit blackbody spectrum.

***COBE* FOUND A PERFECT BIG BANG.** Sixty-seven measurements (the small squares) by the far infrared absolute spectrophotometer show that the temperature of the cosmic background does not deviate from a blackbody spectrum (smooth line) by more than 1 percent. This indicates a smooth, uniform Big Bang. Lumps in the distribution of matter in the early universe would have produced significant variations from the blackbody spectrum. Diagram courtesy of John Mather.

in the wavelength range between 0.5 millimeters and 5 millimeters the intensity of the background radiation varies less than 1 percent from a "blackbody" spectrum. A blackbody is an idealized opaque object that continuously absorbs all the radiation that strikes it (that's why it's called black) and then reradiates all the energy, leaving neither a net gain nor net loss of energy in the object.

The fact that the intensity of the microwave background precisely matches that of a perfect absorber and emitter attests to the fact that matter and radiation in the early universe were in equilibrium, i.e., both had identical temperatures. Thus, according to the FIRAS measurements, the Big Bang was a smooth and uniform event. Had deviations from the blackbody spectrum been detected, these would have indicated energetic processes in the early universe and a clumpier distribution of primordial matter. But no such deviations were detected.

Another instrument aboard *COBE,* the differential microwave radiometer (DMR), was designed to detect variations in the brightness of the cosmic background radiation. George Smoot, principal investigator for the instrument, reported that maps taken at 31, 53, and 90 gigahertz show that the background glow is equally bright in all directions. The previously known "dipole" (or 180-degree) variation was detected, but this is simply a Doppler effect caused by the motion of Earth relative to the background ra-



Choose Your Universe

A new computer-simulated universe shows how the real universe evolved from a smooth state.

A SLICE OF REAL UNIVERSE (this page) looks remarkably similar to the panoramic slice of a computer-simulated universe (opposite page) in which gravity is the dominant force and cold dark matter the dominant mass. As in the real universe, galaxies in the simulated version form "great walls" and filaments surrounding bubble-like voids. Earth is located at the apex of the wedges. Simulation courtesy of Changbom Park and J. Richard Gott; galaxy survey courtesy of the Harvard-Smithsonian Center for Astrophysics.

diation. Subtract that and the radiation is uniform across the sky.

A third instrument, the diffuse infrared background experiment (DIRBE), looked for infrared radiation from the luminous primeval stars and galaxies thought to have formed in the early universe. The instrument's principal investigator, Michael Hauser, said that maps of the sky at 1.2, 12, and 240 microns clearly revealed bright radiation from solar system dust, stars, and interstellar dust. But again, no background structures were apparent.

All You Need Is Gravity

COBE's findings agree with the cosmological principle, which asserts that there are no preferred vantage points in the universe: The view of the cosmos is the same in every direction no matter where the observer is located. Yet when we peer into different parts of the sky with telescopes, we see a variety of structure. Bright stars and clumps of dust and gas favor the disk of the Milky Way, while in directions perpendicular to the disk we see "great walls" of galaxies shot through with immense volumes of empty space. These structures, in fact, may be more extensive and complex than astronomers believed. During the same scientific meeting at which the *COBE* results were announced, an international team of astronomers reported their discovery of *many* walls of galaxies interspersed through billions of light-years of space. (See AstroNews, page 10.)

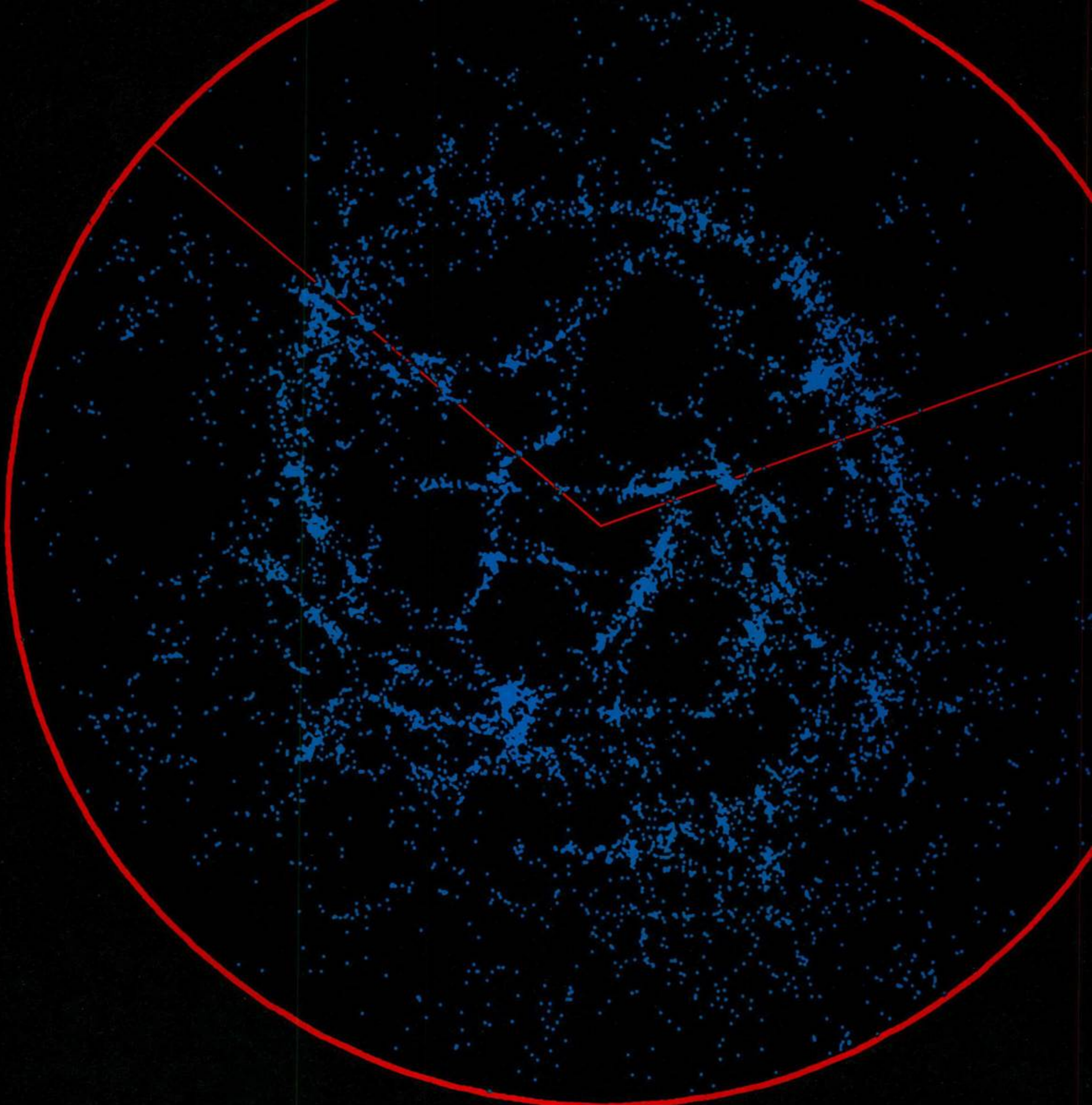
How, then, can the uniformity of the cosmic microwave background be reconciled with the existence of planets, stars, and galaxies? For these objects to exist, there must have been density ripples or wrinkles in the early universe on some scale. What force could have disturbed the universe enough to spawn the rich structure we see today and yet go undetected?

One theory, called explosive amplification, is that colossal blast waves in the early universe swept up and compressed matter into galaxies. Astronomers don't have to look any farther than our own Galaxy to see evidence for this type of explosion on stellar scales. Could a series of primordial explosions of a few exceptionally supermassive objects have ripped through the uniformity of the early universe and formed galaxies on the crests of the resulting shockwaves?

Although such explosions would certainly have had the power to create large-scale structures, the *COBE* results clearly rule them out. Explosions of primeval quasars or supermassive stars would have been very large-scale events that probably would have been seen by the diffuse infrared background experiment. Moreover, the explosion scenario begs the question of how the objects that exploded formed. Unless you resort to further theoretical convolutions, you're back to square one.

Many astronomers, however, are taking a conservative approach. Gravity, they say, can do the trick without all the mayhem. For astronomers like J. Richard Gott of Princeton University, *COBE* confirmed what they had suspected all along. Gott went so far as to say that *COBE*'s results are exactly what you would expect to find if gravity were the primary force moving matter around in the early universe.

"Gravity moves stuff around quietly without redistributing the spectrum of the thermal radiation," said Gott, referring to the isothermal spectrum observed by *COBE*. "If there were violent bursts of en-



ergy in the early universe, you would expect to find distortions in the microwave background. Yet none have been found. That's perfectly consistent with gravity doing the job."

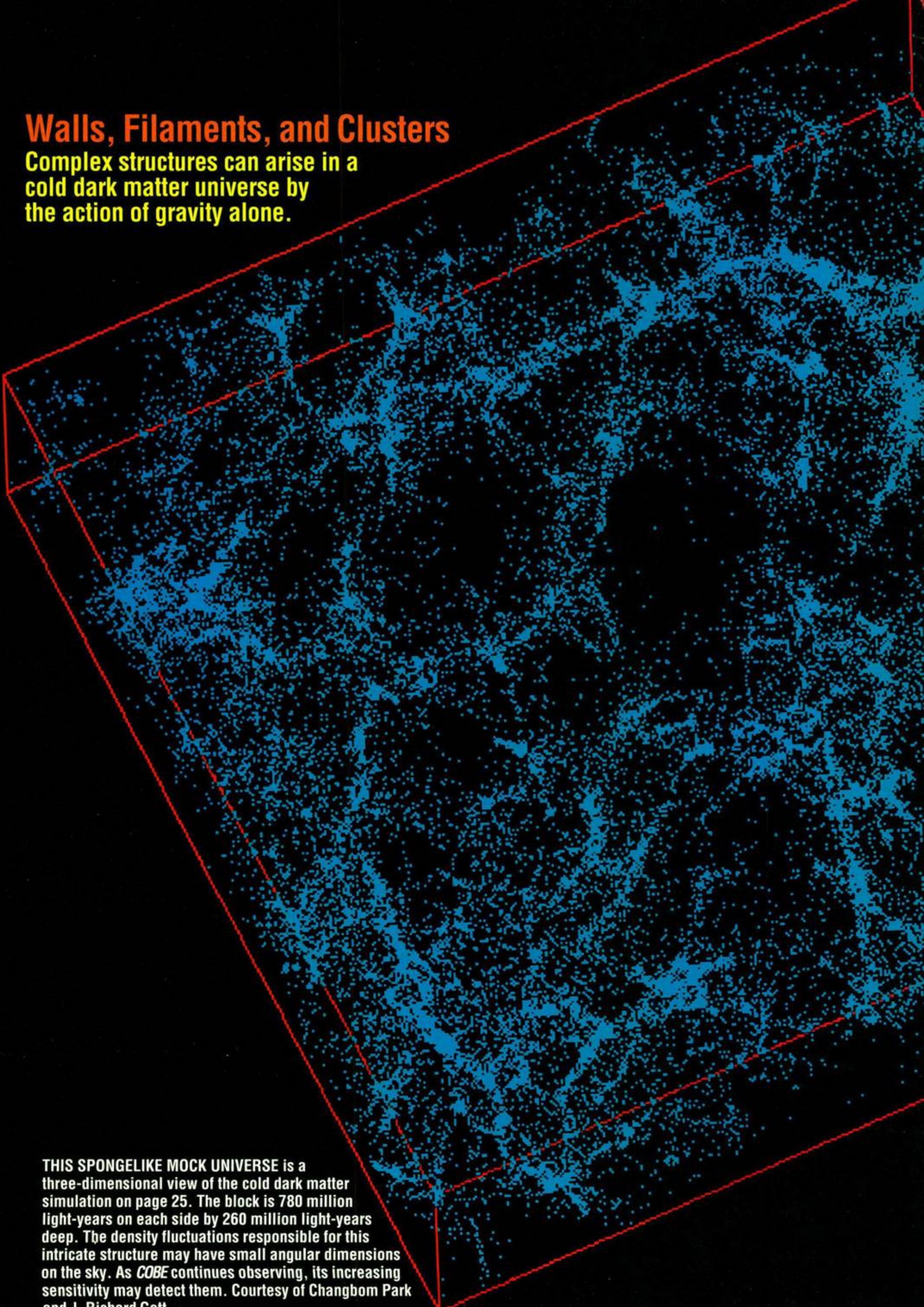
The Cold Dark Matter Solution

One of Gott's graduate students, Changbom Park, recently developed a supercomputer simulation that demonstrates how gravity alone can forge large-scale structure in an initially smooth universe. Park's simulation is based on the extreme form of dark matter called cold dark matter. Cold dark matter is simply a generic name given to a hypothetical group of massive, slow-moving (hence cold) particles such as gravitons, axions, and photinos. Because the cold dark matter particles are heavy and move slowly, much slower than the speed of light, they can be more easily bound together by gravity than "hotter" particles like neutrinos, which are theorized to make up cold dark matter's counterpart, hot dark matter.

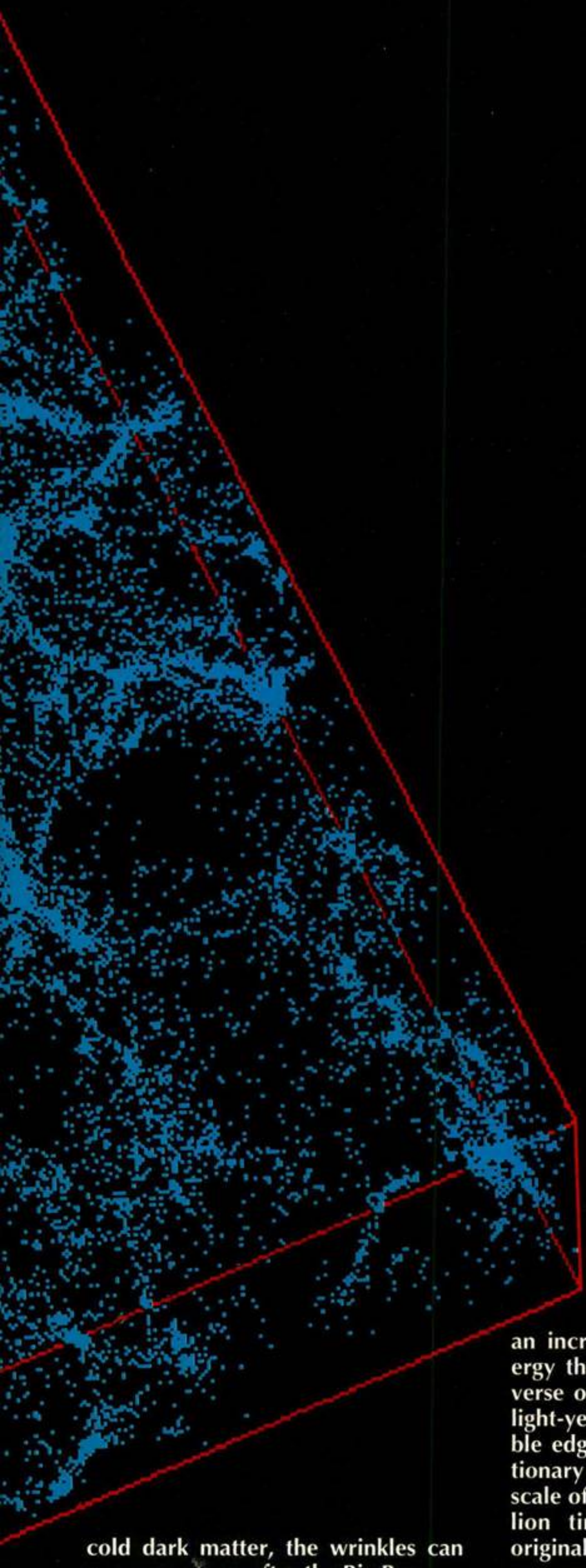
The cold dark matter model predicts that small density irregularities form just 10^{-35} second (ten billionths of a billionth of a billionth of a billionth of a second) after the Big Bang. The irregularities arise from the random motions of the particles as described by the uncertainty principle, which states that we can never know how many particles exist in a certain region of space at any one time. On the quantum level, then, the particles can suddenly amass more in one place than another, forming wrinkles in the otherwise smooth distribution of matter. Because they develop in the sluggish

Walls, Filaments, and Clusters

Complex structures can arise in a cold dark matter universe by the action of gravity alone.



THIS SPONGELIKE MOCK UNIVERSE is a three-dimensional view of the cold dark matter simulation on page 25. The block is 780 million light-years on each side by 260 million light-years deep. The density fluctuations responsible for this intricate structure may have small angular dimensions on the sky. As *COBE* continues observing, its increasing sensitivity may detect them. Courtesy of Changbom Park and J. Richard Gott.



cold dark matter, the wrinkles can grow very soon after the Big Bang.

According to the inflationary model, 10^{-35} second after the Big Bang is a pivotal moment in the history of the universe, for at about that time the universe cooled enough to allow the primordial matter to "freeze" out into more normal matter, like quarks and electrons. This fundamental change in the state of matter — similar to water changing to ice — results in the release of an incredible amount of latent energy that suddenly inflates the universe out to hundreds of billions of light-years, well beyond the observable edge of our universe. The inflationary phase not only extends the scale of the universe ten trillion, trillion times, it also amplifies the original quantum irregularities to macroscopic scales. These congenital wrinkles, like a pattern on a deflated balloon, expand with the universe. By the time the universe is about 10,000 years old, they begin to grow into bigger wrinkles via gravitational instability.

The amplitude of these initial fluctuations are at first very small and can be directly calculated, said Gott. But when the universe is about 110 million years old, the fluctuations become too large to follow with simple mathematical formulae. That's where Park's simulation comes into play. On a supercomputer the program plots the distribution of 4 million particles, half of which represent galaxies and the other half dark matter, and predicts how the distribution looks after 13 billion years if gravity were the only force influencing structure. The universe that emerges looks strikingly similar to the one observed today, including vast voids and great walls and clumps of galaxies.

Park's simulations, said Gott, are in accord with the *COBE* results so far. "I think it's important to remember that the cold dark matter model predicted what *COBE* saw," said Gott. "The *COBE* group has found nothing down to 1 part in 10,000. That means the microwave background is very uniform at the epoch when the universe was about 400,000 years old. The cold dark matter model, however, predicts fluctuations on the order of 1 part in 200,000. That's smaller than the limit of 1 in 10,000, so *COBE* would not have been expected to see the fluctuations yet."

The initial *COBE* results were based on measurements of the sky at an angular scale of seven degrees. But as *COBE* reobserves the sky, the sensitivity of the data will correspondingly increase. John Mather hinted that *COBE* may in fact have already reached the 1 part in 200,000 limit. "It will probably take us about a year to be confident of our results," he said, "but we may already have some parts of the sky that are that good."

With still a year and a half of observations remaining in its mission, *COBE* has already distinguished itself by confirming that the universe began with a hot Big Bang and uniformly expanded and cooled to its present state. Moreover, the isothermal 2.7-kelvins background and its unvarying nature severely constrain the initial conditions necessary for galaxy formation in the early universe.

For now, the cold dark matter model co-exists with the *COBE* observations, but the model's parameters could change significantly before the mission ends. If, somewhere around the magic amplitude of 1 in 200,000, the universe continues to look smooth, cosmologists will have to resort to pulling galaxies out of their theoretical hats. *COBE* may have found the perfect universe, but it remains to be seen how simple or complex that perfection is. ☐

The Case for Density Waves

Sophisticated computer image processing has shown that density waves control the evolution of spiral arms in galaxies.

by David J. Eicher

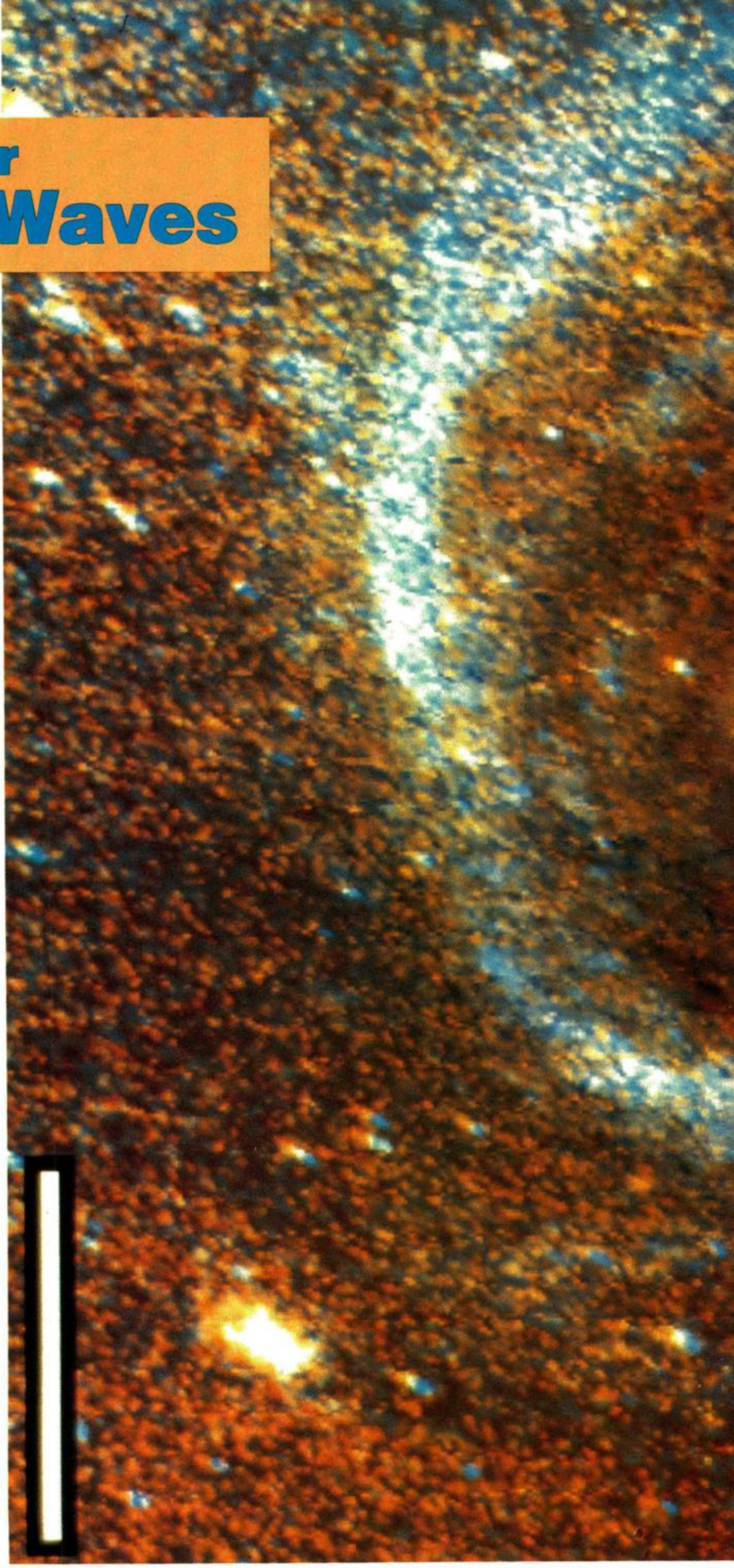
Astronomers using new computer methods and old-fashioned ingenuity have confirmed what they have long suspected: The spiral shapes observed in many galaxies are sustained by density waves.

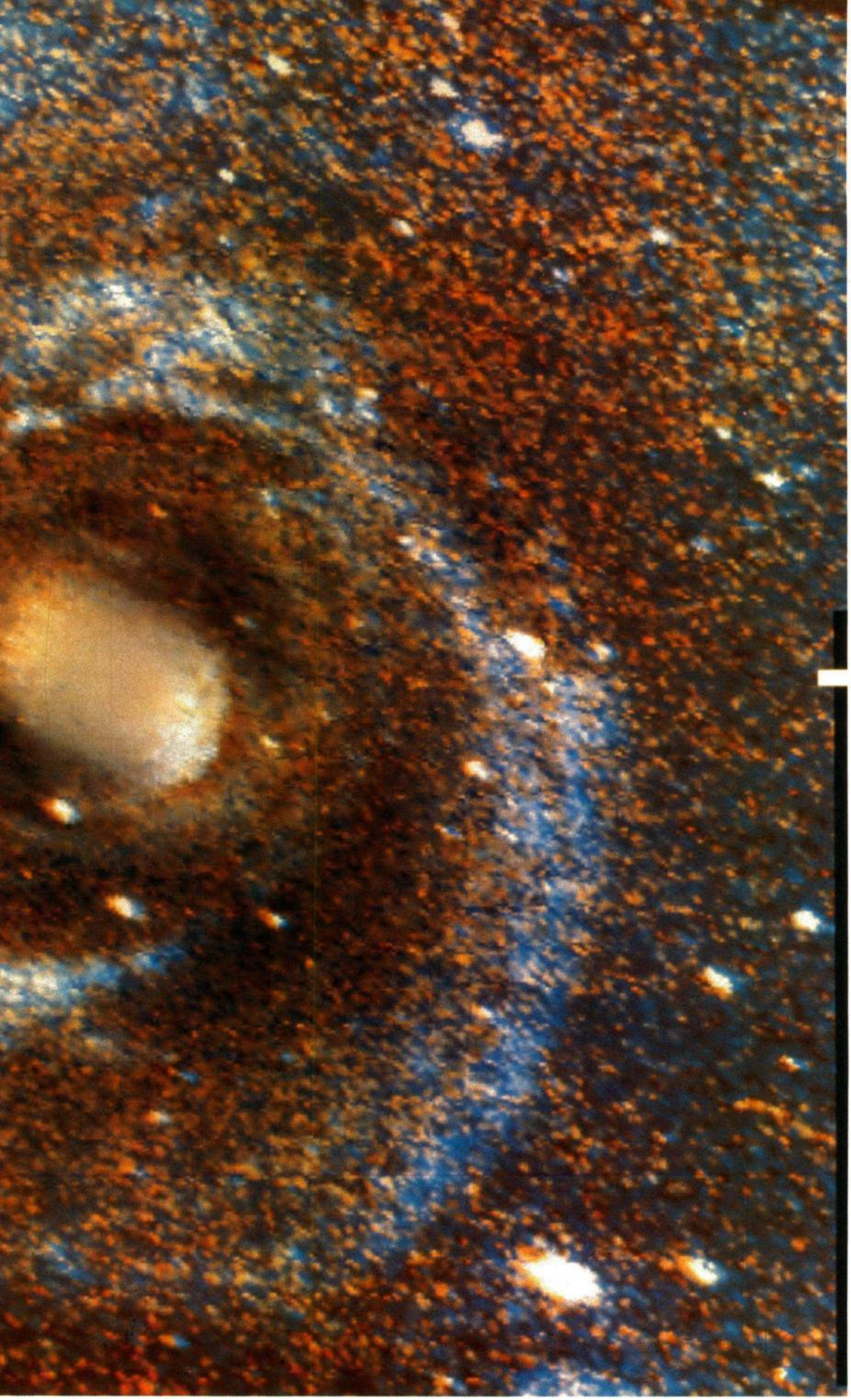
Astronomer Bruce Elmegreen of IBM's Thomas J. Watson Research Center in Yorktown Heights, New York, announced his findings at the January meeting of the American Astronomical Society in Arlington, Virginia. Elmegreen and his associates used a sophisticated computer program to "stretch" an enhanced photograph of the galaxy M81 in Ursa Major to represent its face-on appearance. Once accomplished, this image allowed the astronomers to see gaps in the galaxy's arms that show evidence of density waves in action.

"If you look at a conventional photograph of a galaxy, your eyes can play tricks on you and connect a spiral that's not really connected," said Elmegreen. "When we looked at the enhanced images we could see right away that these spirals are broken, and the breaks occur at the same place on both arms, preserving the overall symmetry."

Elmegreen reported that his image of M81 and two others of galaxies M51 in Canes Venatici and M100 in Coma Berenices show that density waves prevent a peculiar fate for spiral galaxies. Astronomers have long recognized that something must be sustaining the pinwheel shape of spiral galaxies, which rotate at high speeds around their centers. If the spiral arms simply trailed the rotation of the galaxy's hub, the arms would eventually wind up tightly around the galactic core.

Density waves, moving regions in the galaxy carrying contrasting high and low density pockets of stars, regulate a galaxy's overall shape. When





BROKEN SPIRAL ARMS reveal evidence of density waves acting in the galaxy M81 in this computer-processed image. Density waves sustain the spiral patterns in galaxies over long time scales. Photo courtesy Bruce Elmegreen, Thomas J. Watson Research Center.

A NORMAL VIEW of M81 fails to show gaps in the galaxy's arms. After computer processing, hundreds or thousands more galaxies may show evidence of density waves. Palomar Mountain Observatory photo.

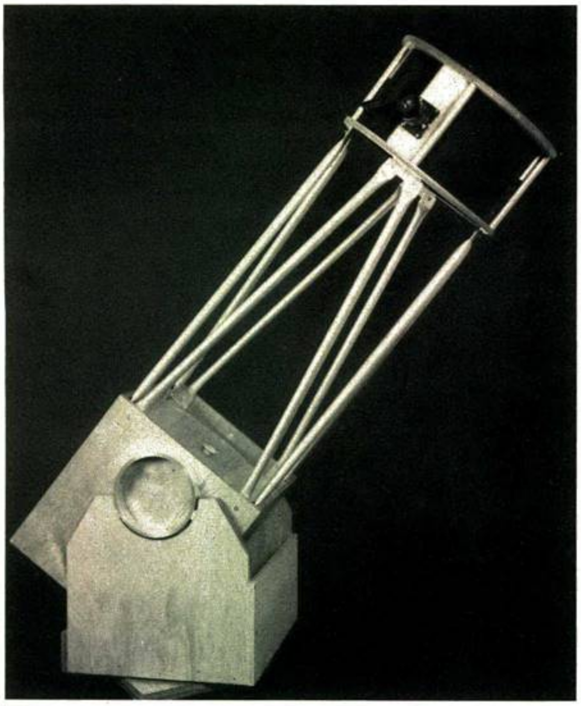
the dense part of a density wave encounters a star, it causes the star to slow down in its orbit, packing numerous stars together like helpless autos in a traffic jam. The dense pockets of stars reinforce the wave's gravity, thus further bunching additional stars.

The newly observed gaps in the spiral arms indicate that the spiral shapes of galaxies are preserved by two sets of density waves moving in opposite directions. The gaps occur in areas where the crest of one wave meets the valley of another. Stars that pass through these areas are not affected at all; they simply continue along their orbits, leaving gaps in the arms.

The first direct proof of the density wave theory comes twenty-five years after the idea was proposed by astronomers C. C. Lin and Frank H. Shu, based on work by Swedish astrophysicist Bertil Lindblad. The most recent incarnation of the theory appeared in an article in the March 1989 issue of the *Astrophysical Journal,* written by Lin, Giuseppe Bertin, S. A. Lowe, and R. P. Thurstans of the Massachusetts Institute of Technology. The theory predicts that two density waves interfering in this way can result in a spiral pattern that persists for several revolutions of the galaxy, thus avoiding the winding dilemma.

The enhanced images produced by Elmegreen also show small "spurs" of stars emanating from the spiral arms of these galaxies. These spurs allow astronomers to identify the significant regions of resonance where repeated encounters with density waves wildly scatter the orbits of individual stars. By finding these regions the astronomers were also able to determine the speeds at which density waves travel through the galaxies.

Just how density waves get started and what their long-term effect on the organization of stars in spiral galaxies is is not yet known. However, Elmegreen and others are busily working to find the answers to these questions. For now, the astronomers are happy to have confirmed one of the longest standing theories about how spiral galaxies behave. □



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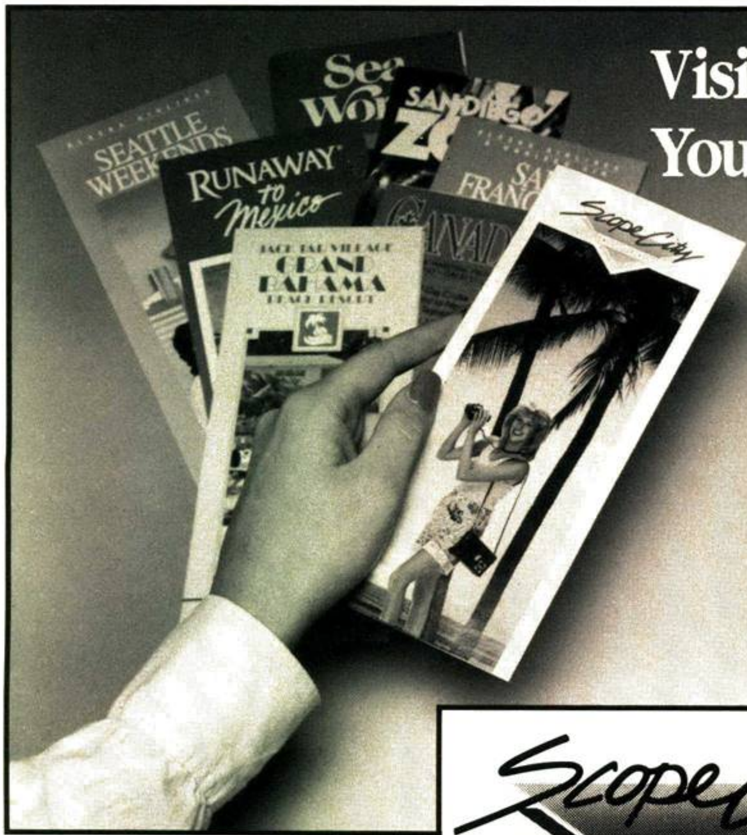

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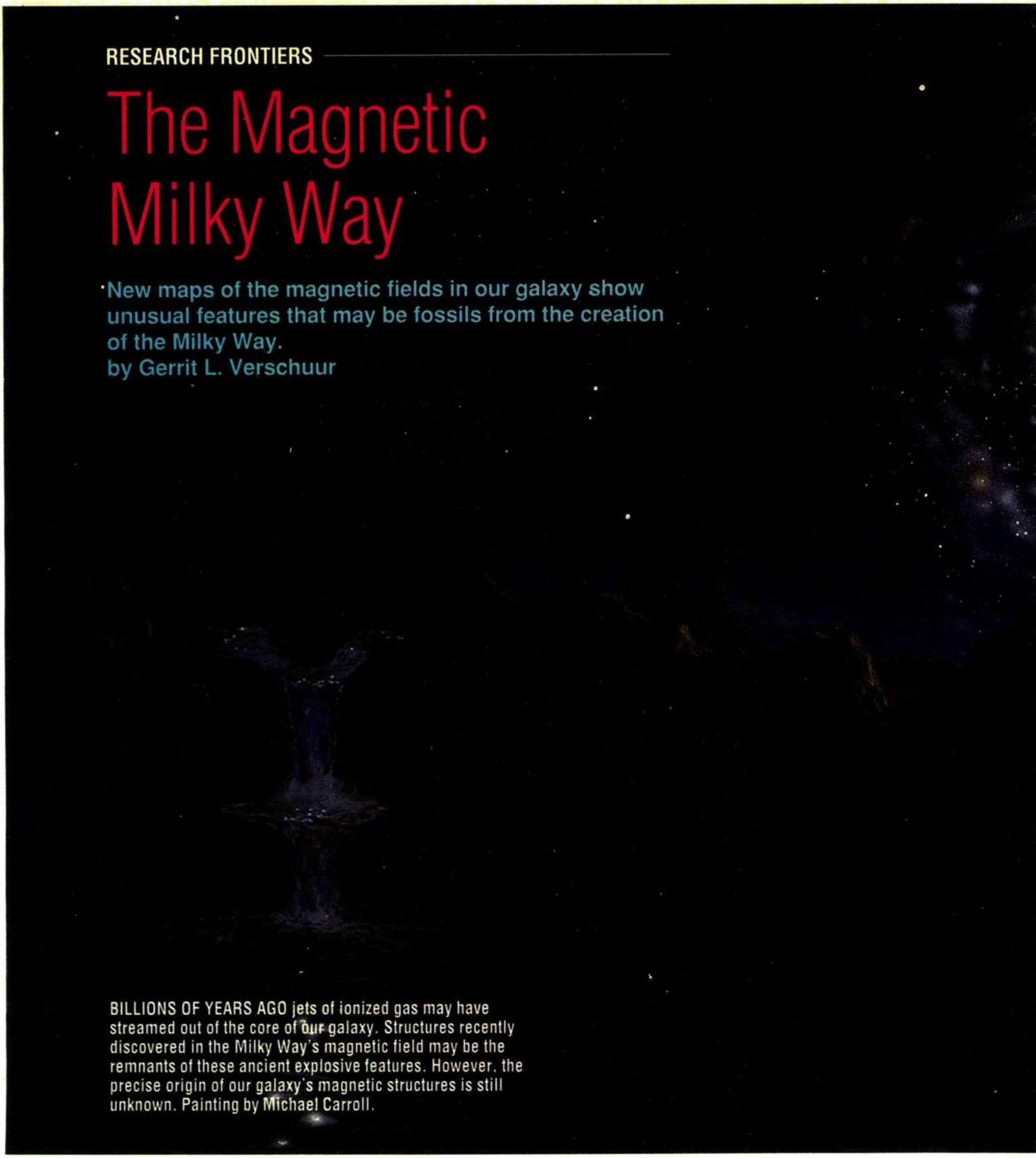
The Magnetic Milky Way

New maps of the magnetic fields in our galaxy show unusual features that may be fossils from the creation of the Milky Way.

by Gerrit L. Verschuur

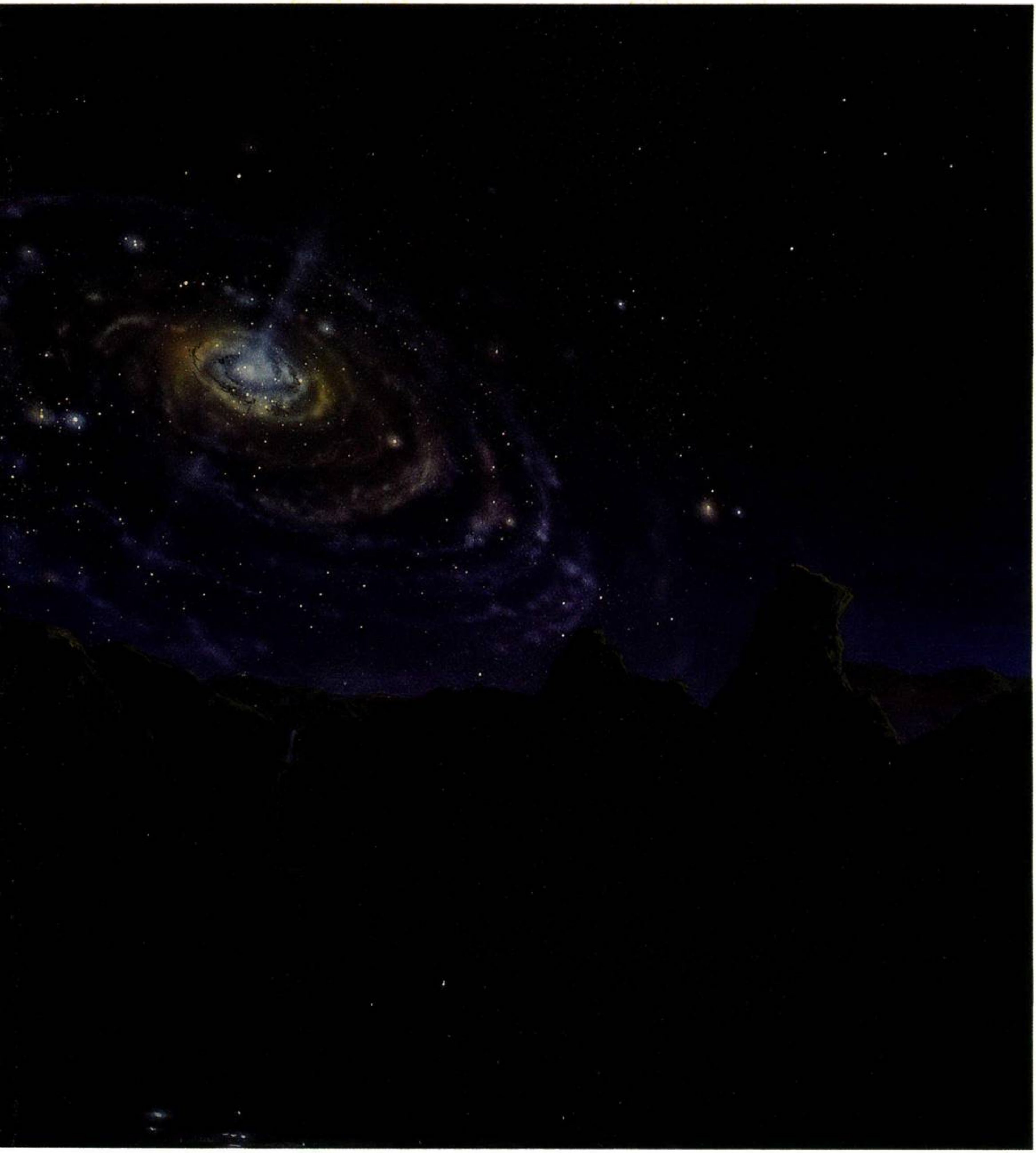


BILLIONS OF YEARS AGO jets of ionized gas may have streamed out of the core of our galaxy. Structures recently discovered in the Milky Way's magnetic field may be the remnants of these ancient explosive features. However, the precise origin of our galaxy's magnetic structures is still unknown. Painting by Michael Carroll.

"Magnetic fields are to astrophysics what sex is to psychoanalysis," wrote H.C. van de Hulst of the Leiden Observatory. The analogy is apt. Magnetism in space is important, but in most situations astronomers prefer not to talk about it. Magnetism is simply too mysterious and elusive.

While magnetism puts its stamp on every form of radiation coming from space, its effects are subtle and difficult to observe. This has created a lack of data, which up to now has given theoreticians a good excuse to ignore magnetism.

Today, that situation is changing. We are beginning to understand that gravity is not the only mover and shaper of material in our galaxy — magnetism is also at



work throughout the spiral arms of the Milky Way. "Improvements in observational techniques in the last decade have opened new ways of studying the role of the magnetic field in the interstellar medium," said Rainer Beck of the Max Planck Institute at a recent conference on magnetism in space.

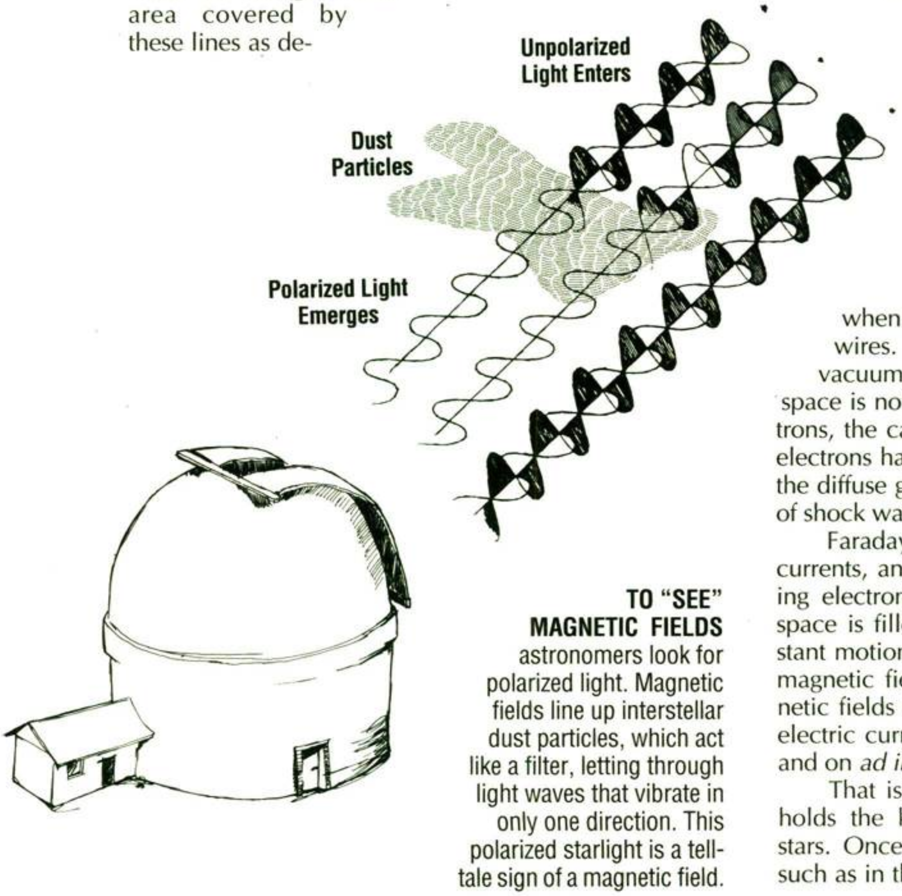
For example, using some of these new techniques a team of Japanese radio astronomers has found an unusual magnetic structure at the heart of our galaxy. "This might be called a magnetic tornado," said Yoshiaki Sofue of the Institute of Astronomy at Tokyo University, conjuring up an image of an enormous swirl of magnetic fields. The tornado is apparently produced by the difference in rotation speeds between the disk of the

Milky Way and the halo of material that surrounds it. It may be the fossil remains of magnetism that once existed in the primeval clouds of gas out of which the Milky Way was born. Today, these magnetic fields twist out of the heart of the Galaxy and stretch along a jet 12,000 light-years long projecting out of the galactic center. This is only one of many new discoveries being made about the magnetic fields in the Milky Way.

From Lodestones to Light

But what are magnetic fields? What, for that matter, is magnetism? It's a force that holds our child's drawings on the refrigerator door, but it also affects the formation of stars and the evolution of galaxies. Mention of magnetic rocks called lodestones, a magnetic oxide of iron, appeared in Greek writings as early as 800 B.C., but for two thousand years little progress was made in understanding the phenomenon. In the thirteenth century it was still believed that a magnet "restores husbands to wives and increases elegance and charm in speech. Moreover, along with honey, it cures dropsy, spleen, fox mange, and burn."

It wasn't until the nineteenth century that physicists began to understand the mysterious force of a magnet. The notion of a magnetic "field" can be traced to Michael Faraday. The third child of a poor blacksmith, he became one of the greatest experimental physicists of all time. A chance reading of the section on electricity in an early nineteenth-century edition of the *Encyclopedia Britannica* stimulated his interest in science. He often sprinkled iron filings on sheets of paper placed over magnets and mused about the fascinating patterns the filings created. It was almost as if the filings were outlining invisible lines of force. He thought of the area covered by these lines as defining a field pervading a region of space around the magnet. A small compass needle would respond to this magnet if it was placed in this field of influence.



TO "SEE" MAGNETIC FIELDS astronomers look for polarized light. Magnetic fields line up interstellar dust particles, which act like a filter, letting through light waves that vibrate in only one direction. This polarized starlight is a telltale sign of a magnetic field.

Although space around a magnet isn't literally filled with invisible lines, this mental picture helped Faraday in his thinking. The concept of a field, subtle and elusive, was a clever way to grasp the notion that something, as yet poorly defined, penetrated space.

Isaac Newton thought the notion of a field absurd. "That gravity should be innate, inherent, and essential to matter, so that one body may act on another at a distance through a vacuum without mediation of anything else...is to me so great an absurdity, that I believe no man who has in philosophical matters a competent faculty of thinking, can ever fall into it," Newton wrote in 1692. Yet he and generations of scientists after him did fall into it, and they learned how to use the notion of fields of force to accurately describe not only gravity but also electricity and magnetism.

The connection between magnetism and electricity was first discovered by Danish scientist Hans Christian Oersted. During a public lecture in 1820 at the University of Copenhagen, Oersted noticed that a magnet close to a wire responded when an electric current passed through the wire. Within a few days he showed that a magnetic field was created around any wire carrying an electric current.

Within a few months Michael Faraday discovered that the converse was also true: a moving magnet could cause a current to flow in a nearby wire. This discovery led to the development of the electric generator, the primary source of electricity in our modern world.

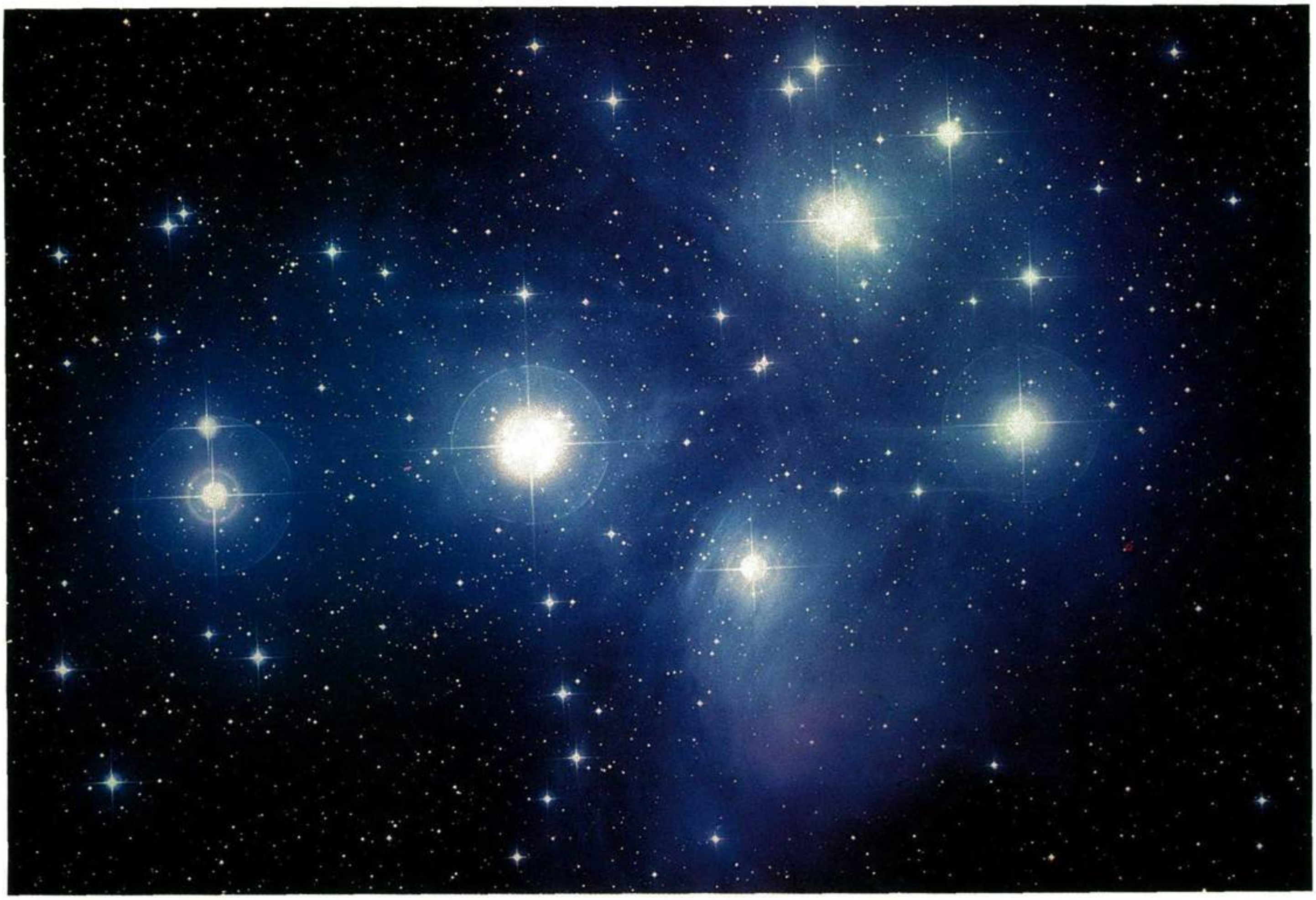
Together Oersted and Faraday had shown that electricity and magnetism were intimately related. The marriage of their two discoveries became the cornerstone for the development of a unified electromagnetic theory by James Clerk Maxwell. This led to an understanding of light and the spectrum of electromagnetic radiation, which astronomers use to explore the universe.

Fields in a Vacuum

It's easy to picture magnetic fields when they surround tangible conductors like wires. But how do we get magnetic fields in the vacuum of space? The answer is that interstellar space is not perfectly empty but is filled with free electrons, the carriers of electric currents. These interstellar electrons have been driven out of their parent atoms by the diffuse glow of starlight or by the shattering impacts of shock waves created when stars disintegrate.

Faraday showed that moving magnetic fields drive currents, and Oersted discovered that currents of moving electrons create magnetic fields. Since interstellar space is filled with electrically charged matter in constant motion you would expect these currents to create magnetic fields. And indeed, they do. But if the magnetic fields also move about, wouldn't that create new electric currents, which then create new fields, and on and on *ad infinitum*?

That is precisely what happens. This endless loop holds the key to explaining magnetism between the stars. Once a field is created in an ionized medium, such as in the core of a star or in the space between the



THE EFFECT OF MAGNETIC FIELDS is visible in the Pleiades cluster. The tiny grains of dust surrounding the Pleiades have been aligned by the magnetic fields around these newborn stars, giving the nebulosity a streaked appearance. Photo from Anglo-Australian Telescope Board.

stars, the field maintains itself because of this ceaseless interplay between currents and magnetic fields. Provided no energy is lost in the process, this dance can continue indefinitely.

Inside interstellar clouds of gas, magnetic fields become "frozen in." They are literally part of the cloud. If the gas moves, the fields move with it, and vice versa. If the cloud contracts, the fields become stronger. They can actually stop the contraction of the cloud because fields do not like to be crowded.

Closer to home, frozen-in fields in the Sun come bubbling to the surface in and around sunspots when small blobs of gas are driven upward. The interaction between segments of frozen-in magnetic fields can cause violent solar explosions known as flares. The role of magnetic fields in the Sun is so important that Caltech astronomer Robert Leighton has said that "if the Sun had no magnetic field, it would be as uninteresting as most astronomers think it is."

Magnetic fields have a way of making things interesting. On the galactic scale, interstellar fields are frozen in, but the motion of stuff between the stars is painfully slow. Unless an exploding star churns things up, the fields in interstellar space, once created, are likely to exist for the age of the Galaxy. This is another way of saying you needn't bother to look for giant refrigerator magnets in space to explain magnetism in the Milky Way — it's all done by currents and fields perpetually interacting with one another.

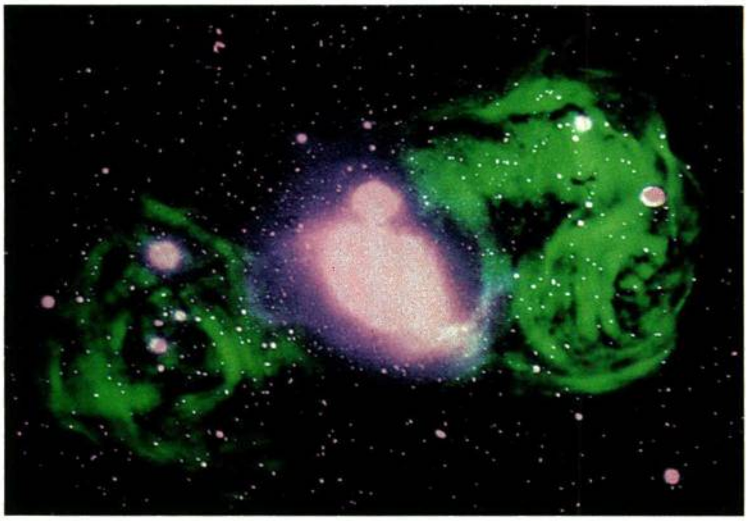
How Do You See a Magnetic Field?

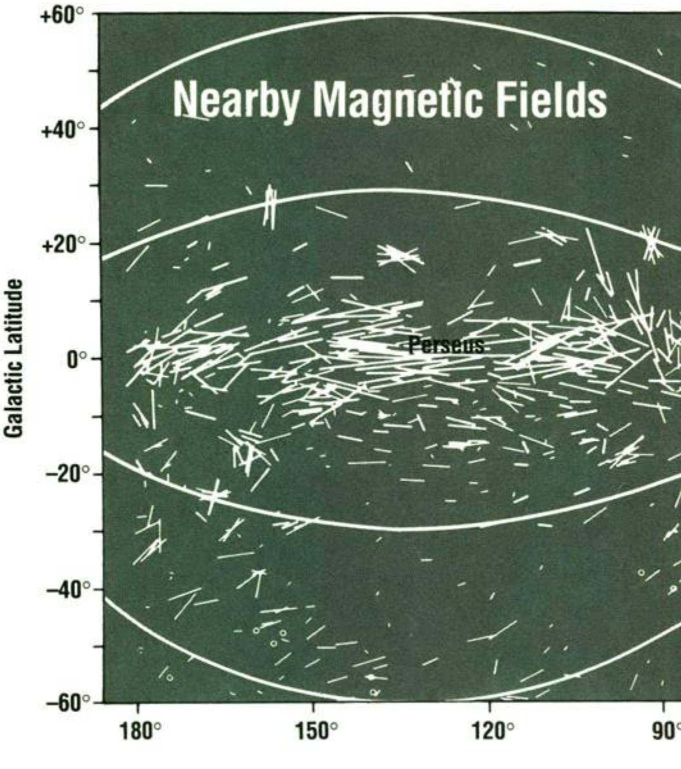
Magnetic fields have two properties: a direction and a strength. Earth's field, for example, converges toward the magnetic poles, which are deep within the mantle. A compass needle points not just north-south but also slightly down. This is the direction of Earth's field.

The strength of our planet's field is about half a gauss, a unit named after Johann Karl Friederich Gauss, a nineteenth-century pioneer in the study of magnetism. By comparison a small magnet has a strength of about 1,000 gauss. The Sun's average field is one gauss and the fields in sunspots average hundreds to thousands of gauss. At the other end of the scale, the feeble Milky Way magnetic fields range in strength from a few microgauss (millionths of a gauss) to several tens of microgauss.

To probe the magnetic fields of the Milky Way, we can't scatter compasses all around the Galaxy. Instead, astronomers look for the amount of polarization in starlight. Radiation traveling through space is like a wave running along a stretched rope. If the rope is flicked up and down a linearly polarized wave is created. In this case its plane of polarization would be vertical. A sideways flick generates a horizontally polarized wave. A third alternative is to rotate one end of the rope to gen-

OTHER GALAXIES HAVE MAGNETIC JETS, like these double-lobed features on either side of NGC 1316 (below). Here a magnetic field map obtained with a radio telescope is superimposed on a visible light photo. Image courtesy of Ed Fomalont, National Radio Astronomy Observatories.





erate a circularly polarized wave.

A beam of starlight, which normally consists of waves vibrating in many different directions, can become polarized when it passes through a dusty nebula. Evidently, magnetic fields influence the orientation of interstellar dust grains causing them to line up, like cosmic iron filings. You can see the effect in the Pleiades star cluster. The nebula surrounding these stars has a streaked appearance caused by the dust particles lining up along the magnetic field lines around these newborn stars.

Magnetically aligned dust clouds act like polarizing filters. When unpolarized starlight encounters a dust cloud, the waves of starlight that are vibrating parallel to the dust particles, and therefore parallel to the magnetic field lines, get through. Light waves vibrating in all other directions are suppressed.

At the telescope astronomers measure the amount and angle of polarization by using filters that work much like Polaroid sunglasses. By rotating the filter and noting the angle at which the star appears brightest, it's possible to measure the direction of polarization for that star's light. This in turn tells us the direction of the magnetic field between us and the star.

Radio waves can also be polarized. If you have ever used an indoor TV antenna, you may have noticed that different channels require the antenna to be oriented either horizontally or vertically. You need to match the polarization of the transmitter to get the strongest reception. This is true for radio waves from space as well. We measure their polarization by rotating the antenna around an axis aligned with the direction from which the radio waves are coming.

The connection between the polarization of light and radio waves from space and galactic magnetic fields was stumbled upon in 1949 when two astronomers, William Hiltner and John Hall, were attempting to measure polarization of starlight by observing eclipsing binary stars. They found the light from the binary stars was unpolarized, which destroyed the theory they had been testing. However, comparison stars *were* polarized. They realized that the degree of polarization was correlated with the amount of interstellar dust through which the stars were shining. It turned out that Hall and Hiltner's observations represented the first evidence for the existence of magnetic fields in interstellar space.

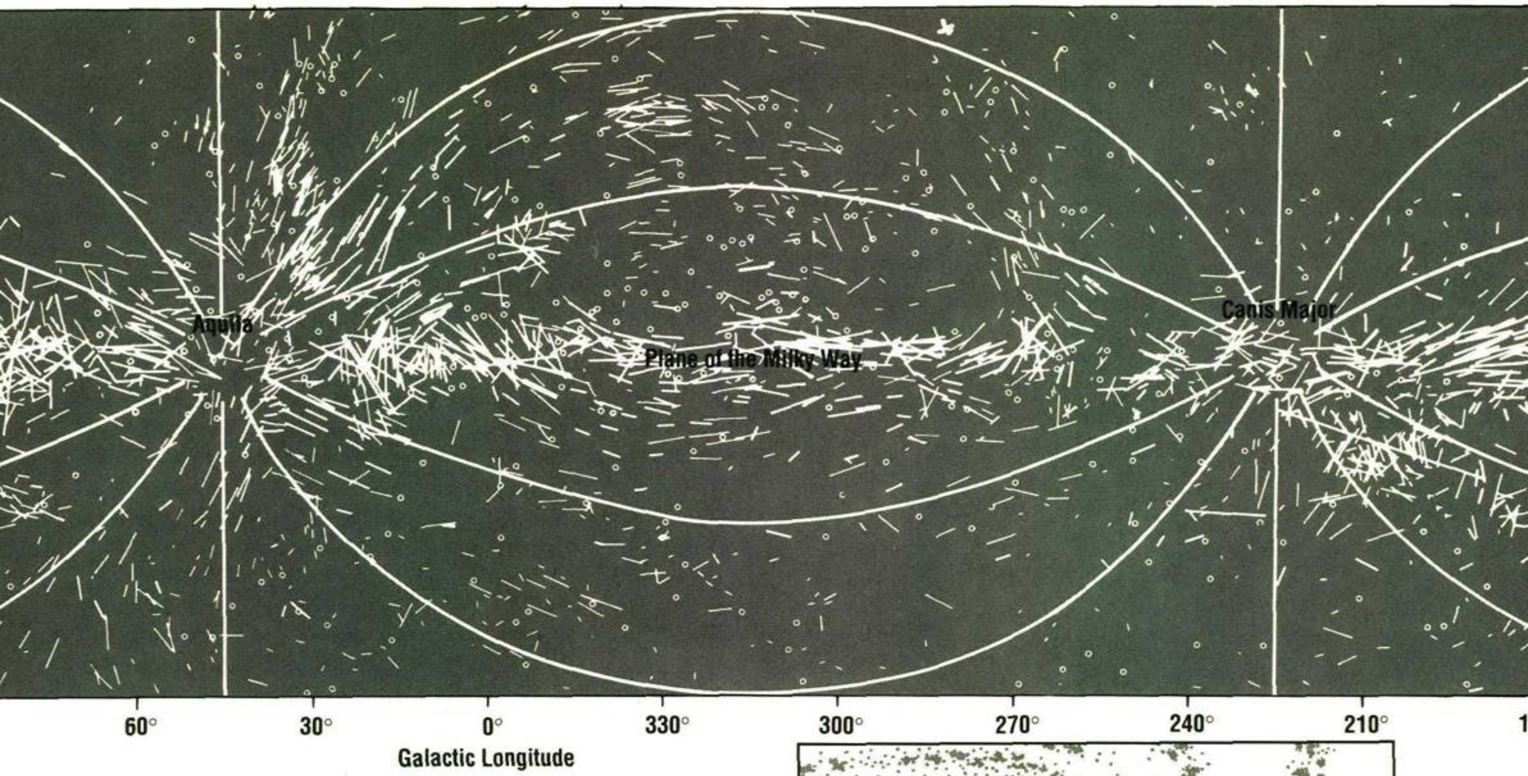
Mapping Magnetic Fields

Since Hall and Hiltner's day optical polarization measurements have been made of thousands of stars. The resulting map (above) shows the structure of the Milky Way's magnetic field out to a distance from the Sun of about 3,000 light-years. This is the region of our local spiral arm.

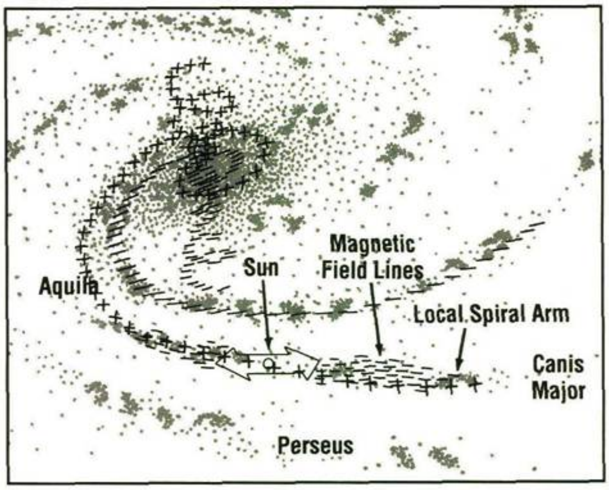
The map reveals that around a galactic longitude of 140° the polarization of stars (and therefore the direction of the magnetic field) neatly parallels the galactic equator. This is through Cassiopeia and Perseus. The map seems to indicate that the field lines at our location in the Galaxy run parallel to the Orion spiral arm in which the Sun is embedded.

However, the map of nearby magnetic fields has some unusual structures. At galactic longitudes of 225° (the Canis Major area) and 45° (in Aquila) we see what appear to be opposite magnetic poles: all the field lines seem to converge on these points. This is a perspective effect caused by us looking down our spiral arm. At those longitudes the field lines are directed toward us or away from us instead of across our line of sight as they are in Perseus.

Another unusual feature is a tongue of bright radio emission projecting above the disk of the Milky Way at about galactic longitude 30°. This feature, called the North Polar Spur, is believed to be the remains of a million-year-old supernova. The field structure is very complex within this shell of gas, now hundreds of light-years



LIKE IRON FILINGS sprinkled around the sky, this map charts the polarization measurements for hundreds of nearby stars. The result is an all-sky plot of the direction of the magnetic fields in our local section of the Milky Way. At the Sun's location the magnetic field lines run parallel to the galactic disk, which runs across the middle of the map. Courtesy Don Mathewson, Mt. Stromlo Observatory, Australia.



WHAT LOOK LIKE OPPOSITE POLES of the magnetic field in the map at the top of the page (at 45° and at 225° galactic longitude) are a perspective effect. When we look in those two directions, we are looking down our local spiral arm, with the parallel magnetic field lines converging in the distance.

in diameter, as it continues to expand away from the site of that long-forgotten explosion.

Determining the structure of the Milky Way's magnetic field helps us create a picture of how interstellar matter moves around the Galaxy. Since interstellar matter is slightly ionized (i.e. electrically charged) and magnetic fields are frozen in, the fields restrict the directions in which the stuff between the stars can travel. This is because electrically charged matter is free to move *along* field lines, but not across them. A map of the Milky Way's magnetic field is therefore also a map of the hidden influences controlling the structure of interstellar matter.

Twisted Light

Another clue concerning the nature of magnetic fields between the stars first emerged in the 1960s. Radio waves from the Milky Way and from other galaxies and quasars were found to be slightly polarized. This polarization originates at the source.

Before reaching Earth this polarized radiation from distant sources undergoes an interesting "twist." It encounters the magnetic fields surrounding the free electrons that permeate all of space. These fields cause the plane of polarization to rotate like a corkscrew. In addition, the angle of rotation is different at different wavelengths. Michael Faraday discovered this basic effect in 1845.

Today, astronomers measure the amount of "Faraday rotation" to determine two important characteristics about magnetic fields: the polarization angle at the source and the direction of the magnetic field between the source and Earth. This technique allows us to map the magnetic field patterns in distant galaxies (see "What About Other Galaxies?" on page 38). In the case of our galaxy the interpretation of Faraday rotation measurements has extended our mapping of the magnetic fields of the Milky Way beyond the local neighborhood of stars to the very heart of the Galaxy itself.

A key result of these Faraday rotation measurements has been the discovery of an unexpected relationship between the Milky Way's magnetic fields and the spiral structure of our galaxy. A map of the sky produced by Philipp Kronberg and his collaborators at the University of Toronto showed that magnetic field lines spiral around our galaxy in a fashion that mimics the

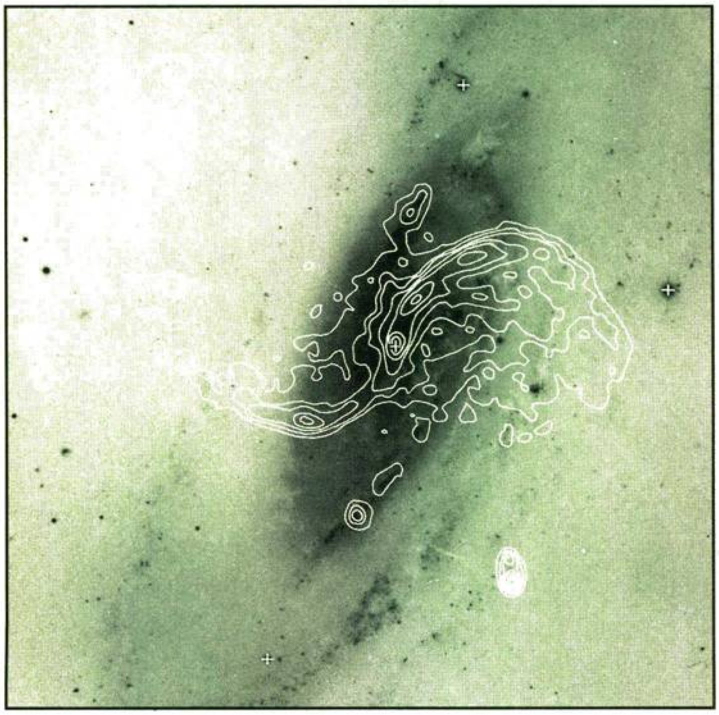
What About Other Galaxies?

The magnetic field lines in the Milky Way seem to parallel the visible spiral arms. The fields reverse their direction from spiral arm to spiral arm, and the field lines run into as well as out of the center of the Galaxy. This type of galaxy, of which there are many, is called a bisymmetric spiral.

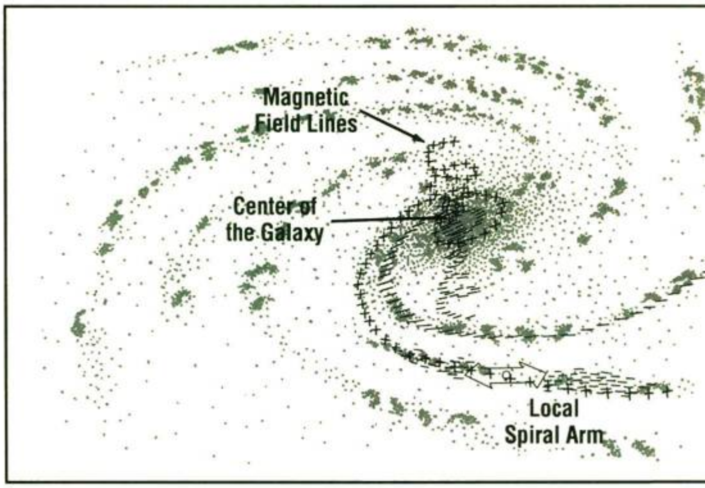
But galaxies are not all the same. Richard Wielebinski, Marita Krause, and Rainer Beck at the Max Planck Institute for Radio Astronomy in Bonn, West Germany, have been mapping fields in nearby galaxies by combining radio and optical observations. They have found that some galaxies, like M31, the Andromeda Galaxy, show nearly circular magnetic fields. Other galaxies show fields either all going into or coming out of their centers where the fields must either enter from or emerge into intergalactic space.

One edge-on spiral, NGC 4631, shows magnetic fields radiating outward above and below the disk. Another odd case, M106, observed by G. D. van Albada, J. M. van der Hulst, and J. H. Oort in the Netherlands, shows magnetic spiral structure in perfect anti-coincidence with the optical spiral arms!

All this suggests that galaxies may be as unique in their magnetic configurations as they are in shape.



THE MAGNETIC STRUCTURES of other galaxies can be very unusual. Unlike in our galaxy, M106 has magnetic field lines that don't coincide with the spiral arms. Image courtesy G.D. van Albada, J.M. van der Hulst, and J.H. Oort



MAGNETIC FIELD LINES SPIRAL around the Galaxy then twist into a tornado-like structure at the center of the Milky Way. The field lines of opposite polarity emerge at the opposite poles of the Galaxy.

visible spiral arms.

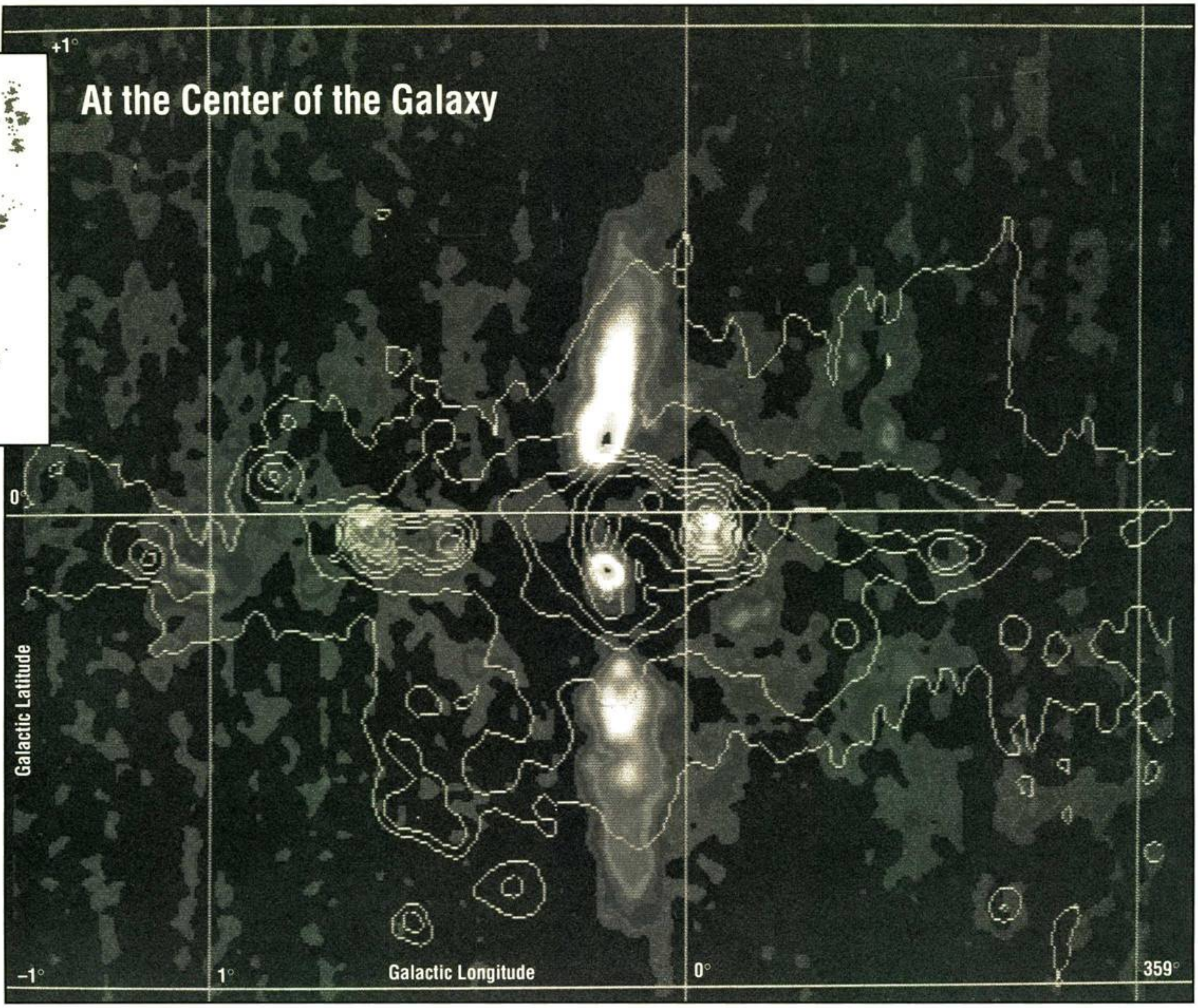
If you could travel toward the center of the Galaxy you would find that the field lines reverse direction; as you crossed the spiral arms your compass would first point one direction then reverse 180°. Outside the Sagittarius spiral arm, located about 6,500 light-years inward from the Sun's location, the magnetic field lines point along the direction of galactic rotation. However, inside the Sagittarius arm the field points the opposite way.

A Magnetic Tornado

It appears that the Milky Way's magnetic field lines form a pair of intertwined and ever-tightening spirals that converge on the center of the Galaxy. A team of Japanese astronomers may have discovered what happens to these spiralling field lines when they reach the Galaxy's core. Masato Tsuboi, Makato Inoue, and other radio astronomers of Nobeyama Radio Observatory, specialists in radio polarization near the galactic center, have found what appears to be a jet of material shooting out of the Milky Way. The magnetic field lines run along this jet forming the "magnetic tornado" at the center of the Galaxy. The tornado is a tiny whirlpool compared to the intense and far-reaching radio jets we see emerging from other radio galaxies and quasars. In fact, the jet in our galaxy may not be active today. What we are seeing may be fossilized magnetic fields left over from an ancient time when the Galaxy erupted with activity.

Yoshiaki Sofue, affiliated with the University of Tokyo, is one of a growing number of researchers who believe the tornado is evidence for a primeval origin of our galaxy's magnetic field. The ancient field has wound up as the Galaxy rotated and is now concentrated near the galactic center where it is tightly coiled.

The picture of our galaxy that emerges is complex. The magnetic field lines passing close to the Sun spiral into the galactic center where they twist up and out of the Galaxy. The field lines running inside the spiral arm between ours and the core region also meet at the galactic core but probably corkscrew out the opposite pole of the Galaxy. *Both sets of coiled field lines diverge into in*tergalactic space where they may ultimately be connected to other galaxies.


At the Center of the Galaxy

AT THE CORE OF THE GALAXY the magnetic structure of the Milky Way shows two plumes emerging from above and below the heart of the Galaxy, each about 650 light-years long. It is not known whether material is still being injected into these jets or whether these are inactive structures left over from the formation of the Milky Way. The field of view in this map is 2° square. Image courtesy Nobeyama Radio Observatory and Utsunomiya University, Japan.

Clearly we cannot visualize magnetic fields in space as consisting of lines connecting poles of magnets located somewhere between the stars. Instead, it appears that the Milky Way's frozen-in magnetic fields have become twisted over the eons as the Galaxy rotated.

Despite the obvious existence of magnetism in the Milky Way, the origin of the field remains a mystery. This is a classic case of deciding which came first. Was it the magnetic field "chicken" or the electric current "egg?" One school of thought invokes some type of powerful electrically charged source in the Milky Way long ago. This dynamo would have created an underlying galactic field that was then distorted and amplified by localized events such as supernovae explosions. Another theory assumes that the primeval magnetic field came first and was wound up as the Galaxy formed. This "seed" field, a remnant of the Big Bang as it were, may have been amplified later within the Galaxy by a dynamo effect.

In learning how to study magnetic fields in the Milky Way, astronomers have come a long way from those superstitious days when a lodestone was thought to cure diseases and revitalize marriages. We now study the magnetic fields of galaxies millions of light-years away. Magnetism, once almost a taboo subject in astronomy, has become a force to be reckoned with in our explanations of the origin of stars and galaxies. □

Gerrit L. Verschuur is a freelance science writer and researcher from Bowie, Maryland. He is the author of Interstellar Matters, published by Springer-Verlag. Verschuur's most recent article, "A New Look at the Crab Nebula," appeared in the May 1990 issue.

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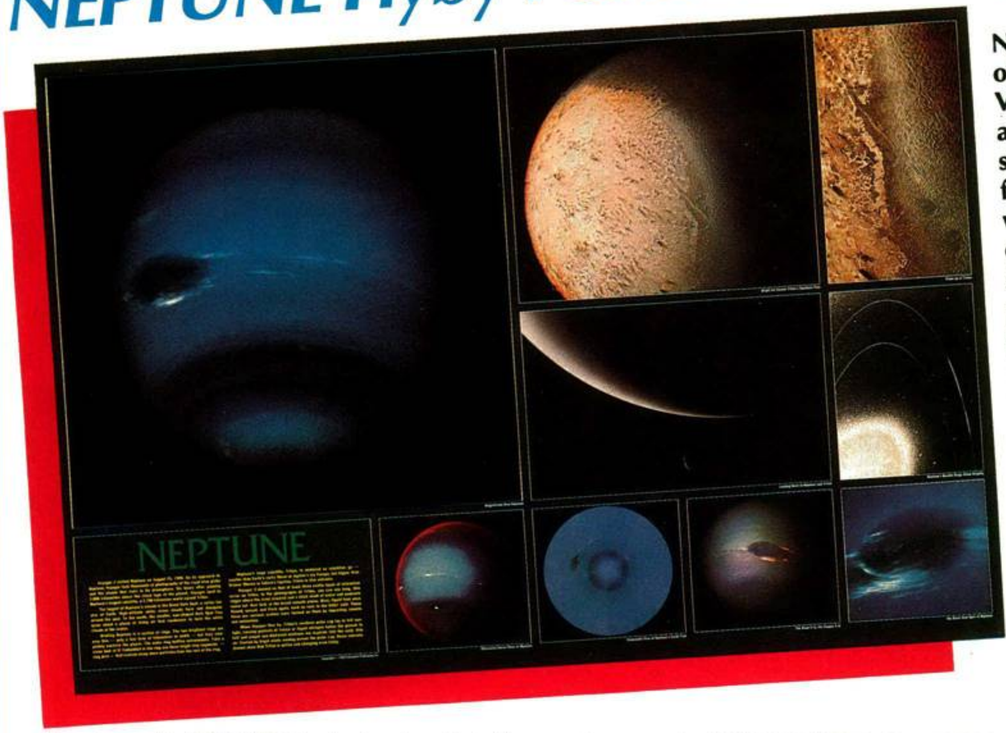

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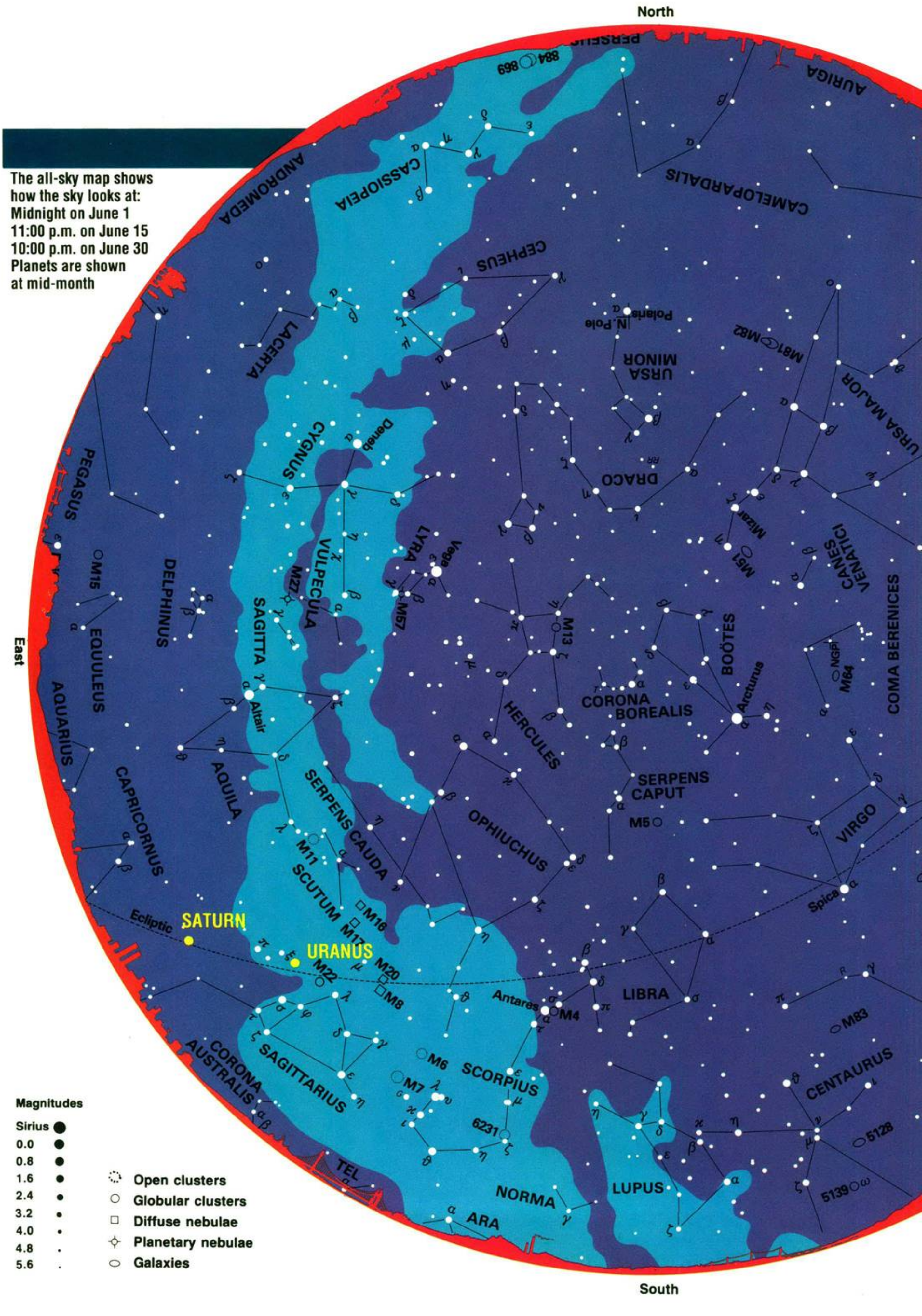
The all-sky map shows how the sky looks at:
Midnight on June 1
11:00 p.m. on June 15
10:00 p.m. on June 30
Planets are shown at mid-month


North
South
East
PERSEUS
884
869
AURIGA
CASSIOPEIA
ANDROMEDA
CAMELOPARDALIS
CEPHEUS
LACERTA
N. Pole
Polaris
URSA MINOR
M81
M82
URSA MAJOR
CYGNUS
Deneb
DRACO
PEGASUS
LYRA
Vega
M57
VULPECULA
M27
SAGITTA
DELPHINUS
M15
EQUULEUS
M13
HERCULES
CORONA BOREALIS
BOÖTES
Arcturus
CANES VENATICI
M51
Mizar
COMA BERENICES
NGP
M64
AQUARIUS
AQUILA
Altair
SERPENS CAUDA
SERPENS CAPUT
M5
OPHIUCHUS
VIRGO
Spica
CAPRICORNUS
M11
SCUTUM
M16
M17
Ecliptic
SATURN
URANUS
M22
M20
M8
Antares
M4
LIBRA
M83
SAGITTARIUS
CORONA AUSTRALIS
M6
M7
SCORPIUS
6231
CENTAURUS
5128
5139
TEL
NORMA
LUPUS
ARA
Magnitudes
Sirius
0.0
0.8
1.6
2.4
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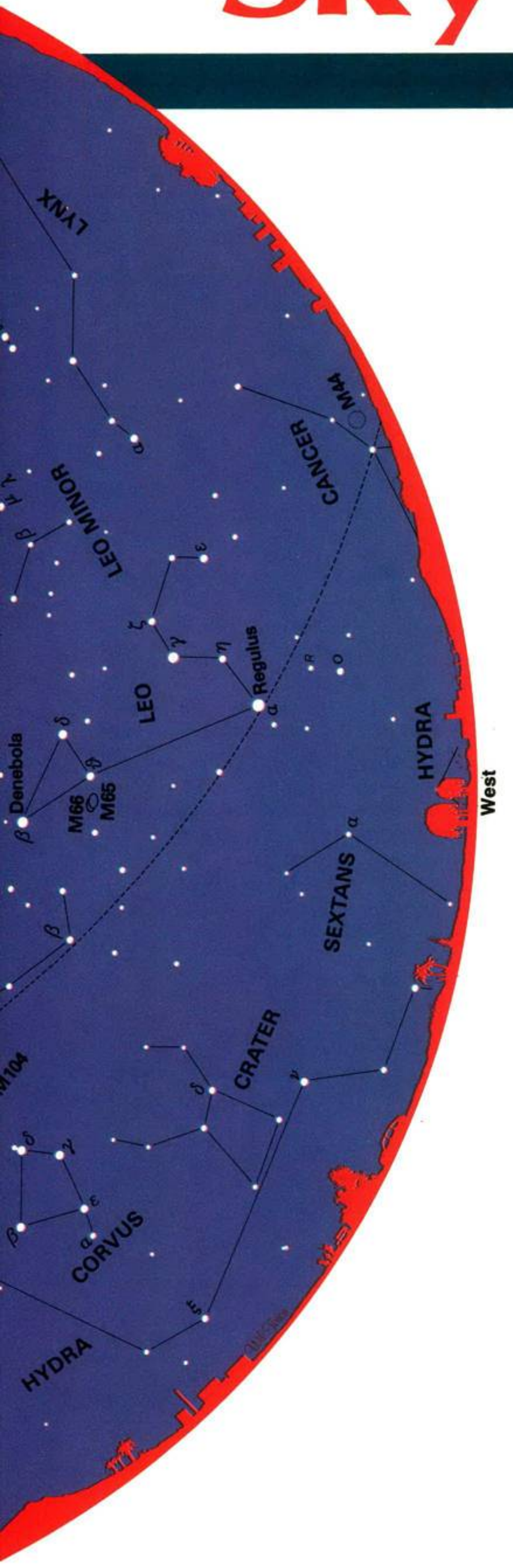
Open clusters
Globular clusters
Diffuse nebulae
Planetary nebulae
Galaxies

Sky Almanac

June 1990



URANUS REACHES OPPOSITION

The outer planet Uranus arrives at opposition on June 29. Although Uranus is far from bright, you can see it with the naked eye in the southeastern sky after evening twilight ends. Telescopic observers should be sure to watch the planet around midmonth when it passes less than 0.5° from the bright globular cluster M22.

COMET AUSTIN VISIBLE ALL NIGHT

If Comet Austin lives up to expectations, it will still be visible to the naked eye in early June. With the comet reaching opposition on June 7, it is well placed for observing all night. However, Austin is now speeding away from both the Sun and Earth, so by late June you'll need binoculars or a telescope to see it.

THE MOON PASSES JUPITER

Jupiter is poised to disappear into the twilight glow at the end of June. But before it does, it forms a pretty pair with a slim crescent Moon. Look for the two low in the west-northwest thirty minutes after sunset on the evening of June 23.

SOLSTICE OCCURS ON JUNE 21

The Sun reaches its farthest point north in our sky on June 21, signaling the start of summer in the Northern Hemisphere and winter in the Southern Hemisphere.

Calendar of Events

6 The Moon is at apogee (252,391 miles from Earth), 12:03 a.m. EDT

7 The Moon passes 0.2° north of Antares, 3 p.m. EDT

8 Full Moon is at 7:01 a.m. EDT

11 The Moon passes 1.4° south of Saturn, 8 a.m. EDT

16 Last Quarter Moon is at 12:48 a.m. EDT

17 Mercury passes 4° north of Aldebaran, 10 p.m. EDT

21 The Moon is at perigee (223,658 miles from Earth), 6:55 a.m. EDT
Summer solstice is at 11:33 a.m. EDT

22 New Moon is at 2:55 p.m. EDT

23 The Moon passes 1.6° north of Jupiter, 6 p.m. EDT

29 Flora is at opposition
Uranus is at opposition
First Quarter Moon is at 6:07 p.m. EDT

30 Mars is at perihelion (128 million miles from the Sun)

Eye on the Sky by Deborah Byrd

CAN YOU SPOT URANUS?

There are no dazzling displays of bright planets near one another this month and no ghostly comets with long tails ornamenting our predawn sky. Instead, June is a month of quiet pleasures.

One of these may be your first glimpse of the planet Uranus. This is the planet whose discovery in 1781 doubled the known size of the solar system and stunned those who assumed no other planets existed. Although Uranus is never very bright, it's now at its brightest for the year because it reaches opposition on June 29.

The planet's smidgen of extra brightness is due to the fact that Earth is closest to Uranus at opposition. This year, however, Uranus is some 6 million miles farther away than at last year's opposition because the planet is slowly moving from its closest point to the Sun in 1966 to its most distant point in 2009. But no matter — at magnitude 5.6 it is still visible to the naked eye from a dark-sky observing site.

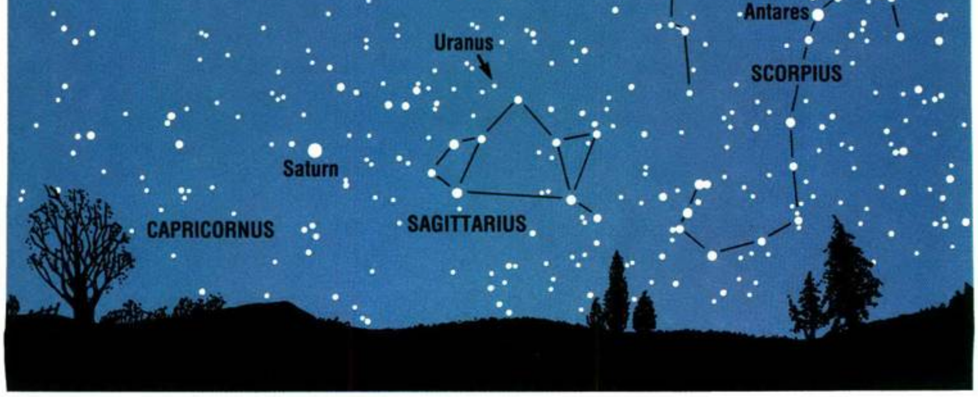
To see Uranus with the naked eye you need a clear night, a dark sky, and a good idea of where to look. (Use the map below to zero in on its location.) First scan the area with binoculars until you think you've found the planet, which has a slight greenish cast. Then set the binoculars aside. Can you still see Uranus? If not, try using averted vision: Look slightly to one side of Uranus' position and the planet should pop into view. Because the First Quarter Moon is in the sky on the night of opposition, try looking for Uranus about a week before opposition in the southeastern sky late in the evening.

LAST CHANCE TO SEE COMET AUSTIN

Comet Austin passed closest to Earth in late May, and as June begins it is heading away from both the Sun and Earth. As it does so it fades rapidly, though you should still be able to glimpse it with the naked eye early in the month from a dark-sky site. Astronomers expect Austin to be near the limit of visibility at this time, so binoculars will definitely improve your view. On June 1 Comet Austin rises in the east-southeast before evening twilight ends and is highest in the south shortly after midnight.

Austin continues to move across the sky from night to night, though its rapid motion of early June slows substantially by month's end. On June 7 it is at opposition, when it rises at sunset, wheels across the sky all night, and sets at sunrise. Unfortunately, the Moon is also opposite the Sun that night and its fully lit hemisphere faces our way. This Full Moon will probably overwhelm your view of the comet.

URANUS APPEARS BRIGHTEST when it is at opposition in late June. Look for the faint naked-eye planet in the southeast above the Teapot asterism in Sagittarius at the end of evening twilight.

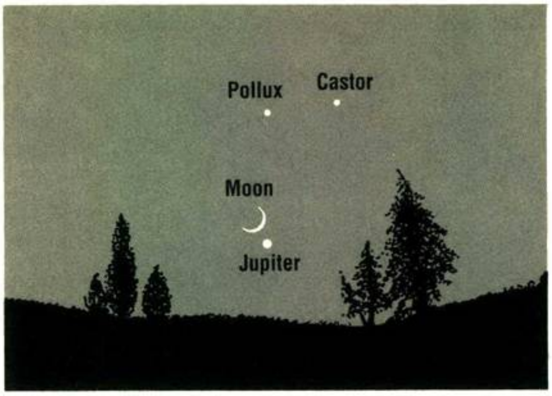


In the first half of June Comet Austin sweeps through the constellations of Sagittarius, Ophiuchus, and Scorpius, where on the night of June 11/12 it lies less than 5° south of Antares, the Scorpion's ruby heart. In mid-June Austin moves into the southern constellation Lupus the Wolf and remains there for the rest of the month. Use the map on page 47 to locate the comet during June.

LONG DAYS AND SHORT NIGHTS

Another less-than-dazzling but still enjoyable June event is the solstice. This year it occurs on June 21 at 11:33 a.m. EDT. The June solstice heralds the moment when the Sun reaches its most northerly point in the sky, which is the official beginning of summer in the Northern Hemisphere.

Perhaps the most surprising feature associated with the solstice is the rising and setting times of the Sun. Although the longest day of the year occurs on the solstice, the Sun does not rise earliest on that day, nor does it set latest. Instead, the earliest sunrise comes a week or so before the solstice and the latest sunset comes a week or so after. The exact dates of earliest sunrise and latest sunset vary with latitude, but the sequence never varies: earliest sunrise, June solstice, latest sunset. The late sunsets at the end of June explain why the days *seem* to continue lengthening after June 21, even though they are actually growing shorter.



YOUR LAST GOOD CHANCE to see Jupiter before it disappears behind the Sun comes on the evening of June 23 when the planet lies close to the slim crescent Moon just above the west-northwestern horizon thirty minutes after sunset.

JUNE'S PLANETS

Jupiter lies low in the west-northwest after sunset in early June. It is impossible to miss because it is so bright, shining at magnitude –1.9. The pair of bright stars just above Jupiter are Castor and Pollux in the constellation Gemini.

By the end of the month the giant planet sinks out of sight in the evening twilight glare. When will you get your last glimpse of Jupiter? The answer depends on how much you want to see it and on your local sky conditions. Casual observers will probably lose sight of it in mid-June. More careful observers may glimpse the planet near the very young Moon on the evening of June 23. As usual, binoculars will keep it in view several days after it is lost to the naked eye.

Saturn, now just one month shy of its July opposition, becomes prominent in the evening sky during June. The planet rises in late evening at the start of the month, but by midmonth it is rising during evening twilight. Look for Saturn in the southeast, where it shines with a soft golden light at magnitude 0.2.

The ringed planet lies among the stars of Sagittarius again this month. As the outermost bright planet, Saturn moves so slowly against the stellar background that it has taken years to traverse this constellation. After several months of moving eastward, away from the prominent Teapot asterism of Sagittarius, last month Saturn began moving westward. That motion continues in June as Saturn edges toward the Teapot again.

Mars brightens noticeably during June, from magnitude 0.6 to 0.3. This is due mostly to its decreasing distance from Earth, but its decreasing distance from the Sun also plays a role. In fact, Mars reaches perihelion, the closest point to the Sun in its orbit, on June 30. Mars now appears more conspicuous in the eastern predawn sky not only because of its increasing brightness, but also because it is pulling away from Venus, whose brilliance makes all other planets pale in comparison.

Venus lies low in the east before dawn. The –4.0-magnitude planet sweeps past the much fainter stars of Taurus in the course of the month. At the end

Early Sunrises and Late Sunsets

The earliest sunrise and latest sunset do not occur on the longest day of the year, June 21, but on dates that vary significantly with latitude. This table gives those dates for several latitudes and lists cities that lie close by.

North Latitude	Earliest Sunrise	Latest Sunset	Nearby Cities
25°	June 9	July 3	Miami
30°	June 11	July 1	Houston, New Orleans
35°	June 13	June 29	Los Angeles, Memphis
40°	June 14	June 28	Denver, Indianapolis, Madrid, New York, Rome
45°	June 15	June 26	Minneapolis, Montreal, Portland (Oregon)
50°	June 17	June 25	London, Paris, Vancouver, Winnipeg
55°	June 18	June 24	Copenhagen, Edmonton, Moscow
60°	June 19	June 23	Anchorage, Stockholm

of June Venus is sandwiched between the famous Pleiades star cluster and the brightest star in Taurus, 1st-magnitude Aldebaran. The Pleiades lie above Venus and Aldebaran below.

Mercury is more elusive this month than usual. Although it remains in the predawn sky for most of June, it is difficult to see. You might catch a glimpse of it below and to the left of Venus during the first half of the month, but you'll probably need binoculars to do so.

JUNE'S STARRY SKY

If you travel into the country this month, perhaps to get a last look at Comet Austin or a naked-eye glimpse of Uranus, take note of a hazy band of light that ascends in the east during the evening hours. It is the famous summer Milky Way, now returning to the evening sky for another season.

This starlit band can be seen easily in late evening this month by anyone who escapes the lights of the city. The summer Milky Way looks so remote and hazy that some people mistake it for a cloud. Yet an ordinary pair of binoculars will show you that this is no cloud. Even with just a little optical aid, the haze resolves into myriad glittering stars.

All of these stars, and in fact every star visible to the naked eye, lie within the confines of the Milky Way Galaxy. The Galaxy's disk is estimated to be more than 100,000 light-years across, but it is only a few thousand light-years thick. That is why the starlit band of the Milky Way appears so well defined in our sky.

Our Sun is located about two-thirds of the way out from the center of the galactic disk. As Earth travels around the Sun each year, our night sky points in different directions. In winter it points toward the outer edge of the Galaxy, and as a result the winter Milky Way appears relatively sparsely populated with stars. The summer Milky Way, on the other hand, is rich in stars because we are facing the heart of the Galaxy where the vast majority of its stars reside.

We can't see stars in the exact center of the Galaxy, however, because they are obscured by stars in the foreground and by intervening clouds of gas and dust. The stars in the summer Milky Way belong to the spiral arm next inward from us, called the Sagittarius Arm.

The constellation Sagittarius marks the direction toward the center of the Galaxy. In mythology this constellation represents an Archer, but it is most readily identified in our sky by bright stars in the shape of a Teapot. The direction to the center of the Galaxy lies about 5° west of the Teapot's spout.

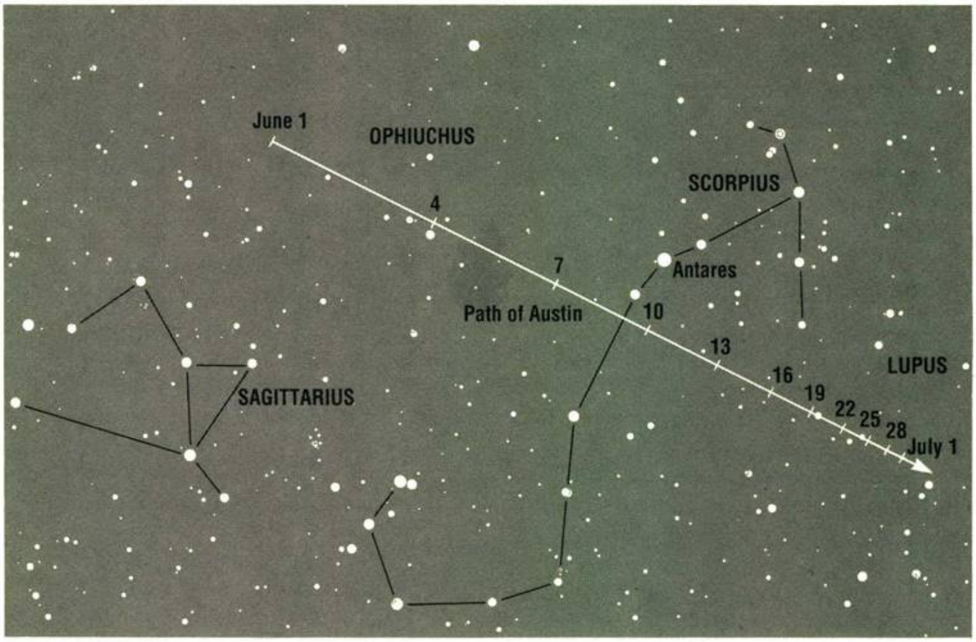
The starlit trail of the summer Milky Way is a treat for naked-eye and binoculars viewers. It is crowded with stars, open clusters, and bright and dark nebulae. For your first experience with the summer Milky Way, leave your charts and books at home. Lie back in a lawn chair under a dark sky. Relax. Smell the country air and listen to the singing of the nocturnal insects. Gaze upward and explore the Galaxy with a stargazer's best tools, your eyes and imagination.

THE SUMMER MILKY WAY rises majestically over the Texas Star Party. Photo by Mace Hooley.

Through the Eyepiece by Rick Shaffer

COMET AUSTIN'S LAST HURRAH

As June begins Comet Austin is moving rapidly away from both the Sun and Earth, probably never to return. Based on observations made earlier this year, astronomers have been able to pin down the comet's orbit quite accurately. They conclude that Austin most likely is a new comet — one making its first passage through the inner solar system — and that barring some unforeseen perturbations it will not return.



COMET AUSTIN enters June as a naked-eye object, but fades rapidly. You'll need binoculars or a telescope to spot it by month's end. Positions are shown at 10 p.m. PDT (11 p.m. MDT, midnight CDT, and 1 a.m. EDT).

Unfortunately, it is more difficult to predict the brightness of a new comet than it is a periodic comet. As we went to press with this issue in mid-March, Austin appeared to be brightening more slowly than many astronomers had predicted, the opposite of its behavior in January and early February. The upshot of this is that no one is sure how bright the comet will be in June. The best guess is that it should be at or near naked-eye visibility in early June and fade to 8th or 9th magnitude by month's end.

Your best chance to view Comet Austin is during the first few days of the month. On the 1st the comet rises in the east-southeast at the end of evening twilight and is a healthy 30° above the southern horizon shortly before morning twilight begins. On June 7 Austin is at opposition and thus in the sky all night long. Unfortunately, the Moon is Full around the same time and you won't be able to see the comet well. When the Moon moves out of the way again in the latter part of June, you can find Austin nearly due south at the end of evening twilight. It lies about 25° above the horizon if you live at 30° north latitude, 15° above the horizon at 40° north, and only 5° above the horizon at 50° north.

You can expect Austin to look like a large, fuzzy, out-of-focus "star" with little or no tail. Because Austin reaches opposition this month, its tail, which always points away from the Sun, is directed away from Earth. Thus, even if Austin's tail stretches millions of miles through space, it will appear short to us.

Despite Austin's short tail in June, you may still be able to catch the comet's long tail in mid-May. To get a rough idea of the tail's length, hold your hand at arm's length. The long dimension of your clenched fist subtends an angle of about 10° and your spread fingers subtend an angle of about 20° from thumb to little finger. With some practice you should be able to measure the tail's length to within 1° or 2° using this technique.

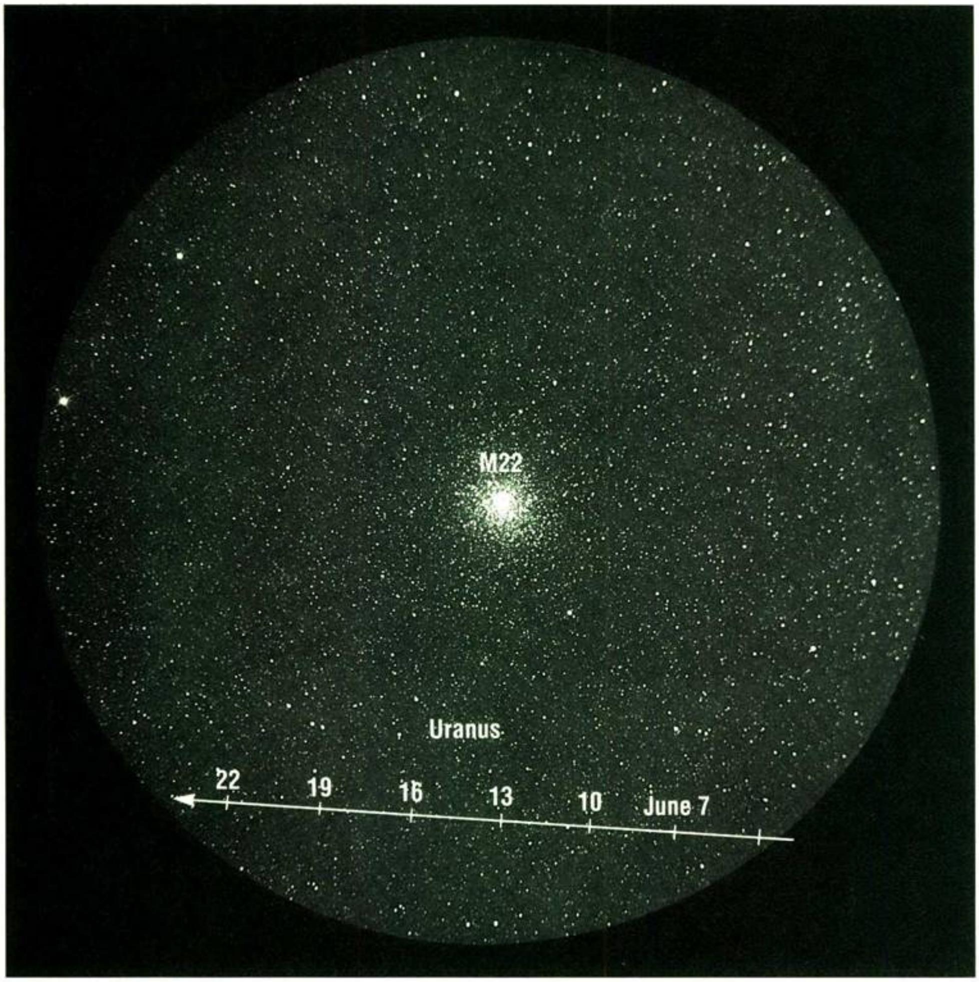
However, with a little effort you can build a modern version of an ancient device that will let you measure angles in the sky more elegantly and accurately. This instrument, called a cross-staff, allows you to determine angles to better than a quarter degree.

There are two main elements to the device: a curved cross-piece on which you lay out an angular scale and a staff that holds the cross-piece at a fixed distance from your eye. You can make an inexpensive cross-staff out of spare wood and materials you have around the house.

I recommend using a piece of 1x2 lumber for the staff and a piece

COORDINATES FOR COMET AUSTIN

Date	R.A. (2000)	Dec.
June 1	17h54.4m	–19°27'
June 4	17h20.9m	–24°22'
June 7	16h54.0m	–27°44'
June 10	16h32.8m	–30°01'
June 13	16h16.1m	–31°36'
June 16	16h03.0m	–32°42'
June 19	15h52.7m	–33°30'
June 22	15h44.6m	–34°06'
June 25	15h38.2m	–34°33'
June 28	15h33.3m	–34°54'
July 1	15h29.5m	–35°10'



URANUS SKIRTS M22 this month, coming within 0.4° of the globular cluster at midmonth. Positions are shown at 10 p.m. PDT (11 p.m. MDT, midnight CDT, and 1 a.m. EDT); south is up to match the view in a telescope. Photo by Jack Newton.

COORDINATES FOR URANUS

Date	R.A. (2000)	Dec.
June 7	18h37m23s	–23°29'06"
June 10	18h36m54s	–23°29'35"
June 13	18h36m24s	–23°30'03"
June 16	18h35m53s	–23°30'32"
June 19	18h35m22s	–23°31'01"
June 22	18h34m51s	–23°31'29"
June 25	18h34m19s	–23°31'57"

of thin molding or a discarded wooden yardstick for the curved cross-piece. The critical dimension of the cross-staff is the distance from your eye to the scale. In this model each half inch on the scale subtends an angle of 1°, so the scale must be exactly $28\frac{5}{8}$" from your eye. Because the staff rests on your cheek and your eye is about a quarter inch farther from the scale than your cheek, the staff should be $28\frac{3}{8}$" long.

The length of the cross-piece is up to you. Mine is 30" long, which allows me to measure angles up to 60°, but you can make it smaller if you like. Just remember, the largest angle you can measure (in degrees) is twice as big as the cross-piece is long (in inches). To attach the cross-piece to the staff, use strong twine or picture-hanging wire. Pass the wire around the cross-piece lengthwise and then forward to the end of the staff. Then adjust the length of the bow string so that the scale lies as close as possible to a radius of $28\frac{3}{8}$" from the end of the staff.

A few added touches will enhance your cross-staff. Cut the leftover piece of the 1x2 lumber into two pieces about 3 inches long and use them to reinforce the joint where the staff and the cross-piece meet. You should also round the eye-end of the staff so the staff pivots easily on your cheekbone. Finally, either sand the end or put a strip of foam tape or thin rubber on the end of the staff to protect your face.

You're now ready to put the scale on the cross-piece. Paint the cross-piece black and then carefully lay out marks every half inch. Rather than paint white degree marks on the scale, go to an auto supply store and buy white pinstriping tape. You can usually get the tape in widths of exactly 1/2", which allows you to mark 1°-wide blocks by alternating strips of tape and no tape. Label the scale with numbers from the auto parts store or buy some stick-on numbers at a stationary store. Once you've completed the project, you'll have a device you can use over and over to measure comet tail lengths, distances between stars, or any other angular distance you want.

URANUS MEETS M22

The planet Uranus reaches two milestones this month. On June 29 it is at opposition, when it is closest to Earth and best placed for observing. And during mid-June it passes just north of the globular cluster M22. The two are closest on the night of June 13/14, when Uranus lies 0.4° from the cluster's center, but they remain quite close for a good part of the month. At magnitude 5.6 Uranus easily outshines the individual cluster members.

Not only is this close conjunction worth observing visually, it is also a wonderful photo opportunity. Astrophotographers might want to take one or two exposures of the pair each clear night from about June 6 to June 20. The resulting photo series will show the relative motion of the cluster and planet and be a vivid reminder of this rare event.

TELESCOPIC PLANETS

Mercury is in the midst of an unfavorable morning apparition as June begins. The innermost planet was at greatest elongation on May 30/31 and on the morning of June 1 it lies 5° above the eastern horizon thirty minutes before sunrise. On that date Mercury shines at magnitude 0.5 and shows a 40-percent-lit, 8.1"-diameter disk.

Although Venus is not much better positioned than Mercury, it is much easier to see because it's so much brighter. The –4.0-magnitude planet lies 20° above the eastern horizon at sunrise and displays a 13"-diameter disk that is 79-percent lit.

Mars continues to grow larger in apparent diameter in June, swelling to 7.8" across by month's end. At that time the 85-percent-lit gibbous disk shines at magnitude 0.3 and is conspicuous in the east before dawn. The most prominent feature on Mars is the south polar cap, but you should also notice a few dusky surface markings. Over the next few months Mars grows appreciably in size and your view at the eyepiece improves dramatically.

Your last good views of Jupiter at this apparition probably came last month. The giant planet is low in the west-northwest after sunset in June and sets by the time twilight ends. Although the 32"-diameter disk of Jupiter shines at magnitude –1.9, the normally poor seeing near the horizon prevents you from getting a sharp view.

While Jupiter slowly disappears into the twilight glow, its outer neighbor Saturn becomes well placed for telescopic viewing. Saturn reaches opposition in mid-July, so in June the ringed planet rises in mid to late evening and is at its highest in the south after midnight. Saturn brightens slightly this month, from magnitude 0.3 to 0.1, and its equatorial diameter grows from 17.9" to 18.3". Saturn's rings also increase in size this month, from 40.7" to 41.8" across, and are inclined 23° to our line of sight.

The most obvious feature of Saturn's ring system is Cassini's division, a gap in the rings about two planet-radii from the center of Saturn. On nights of excellent seeing you may also see a gap in the outer A ring — Encke's division — with a moderate-aperture telescope.

Neptune continues to move slowly through Sagittarius this month. Like Saturn, it reaches opposition in July. Unlike Saturn, however, Neptune has little to offer telescopic observers. You won't see any surface details on the planet's 2.3"-diameter, 7.9-magnitude disk.

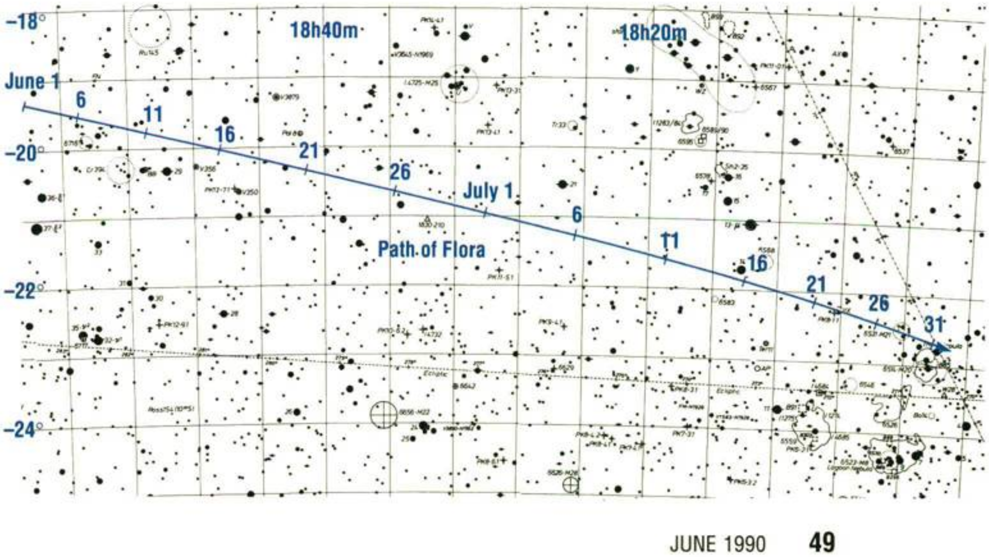
ASTEROIDS IN THE EYEPIECE

Minor planet 8 Flora reaches opposition on June 29. It shines at magnitude 9.0, which makes Flora the second-brightest asteroid to reach opposition in 1990. To identify Flora, find the asteroid's approximate position with the map or table at right. Then observe that area at low power and photograph or sketch what you see. Repeat the observation a night or two later. The "star" that shifts position is Flora. ☐

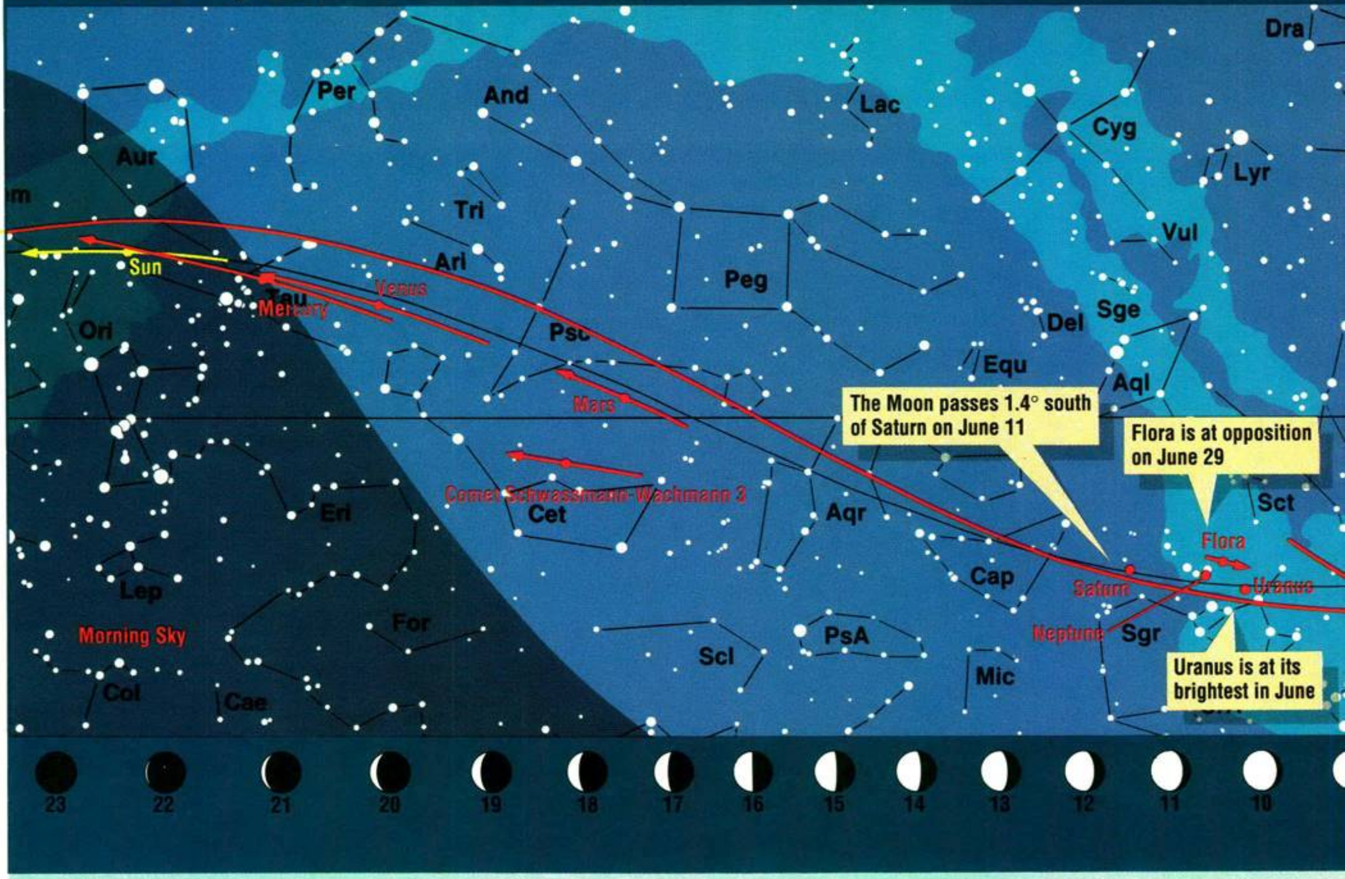
COORDINATES FOR FLORA

Date	R.A. (2000)	Dec.
June 1	18h58.4m	–19°21'
June 6	18h55.0m	–19°33'
June 11	18h51.0m	–19°47'
June 16	18h46.4m	–20°03'
June 21	18h41.2m	–20°20'
June 26	18h35.7m	–20°38'
July 1	18h30.0m	–20°57'
July 6	18h24.4m	–21°15'
July 11	18h18.9m	–21°33'
July 16	18h13.8m	–21°51'
July 21	18h09.2m	–22°08'
July 26	18h05.3m	–22°25'
July 31	18h02.2m	–22°41'

ASTEROID 8 FLORA treks across Sagittarius during June and July, reaching 9th magnitude at opposition on June 29. Positions are shown at 10 p.m. PDT (11 p.m. MDT, midnight CDT, and 1 a.m. EDT). Adapted from *Uranometria 2000.0*, ©1987 Willmann-Bell, Inc.



The Solar System June 1990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Equ
Aql
Mars
Sct
Flora
Comet Schwassmann-Wachmann 3
Eri
Cet
Aqr
Uranus
Saturn
Cap
Lep
Neptune
Sgr
For
Morning Sky
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The Moon passes 1.4° south of Saturn on June 11

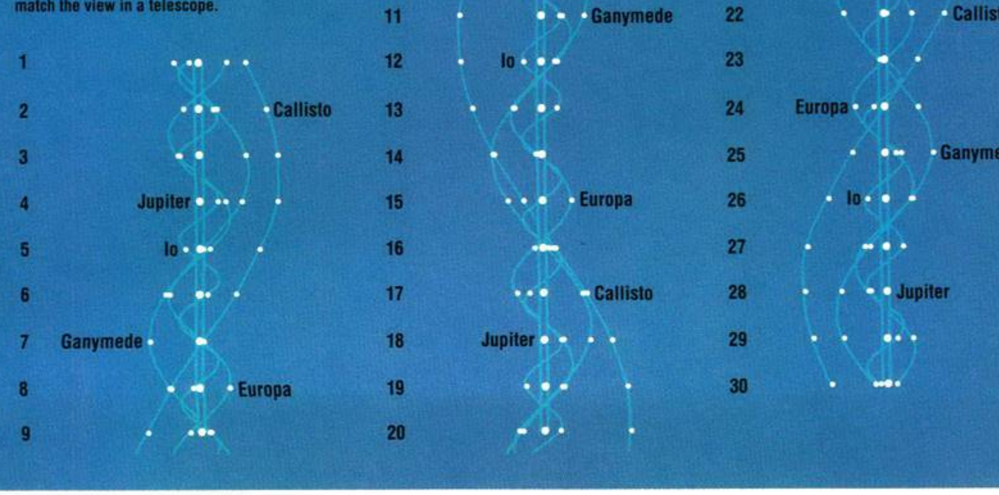
Flora is at opposition on June 29

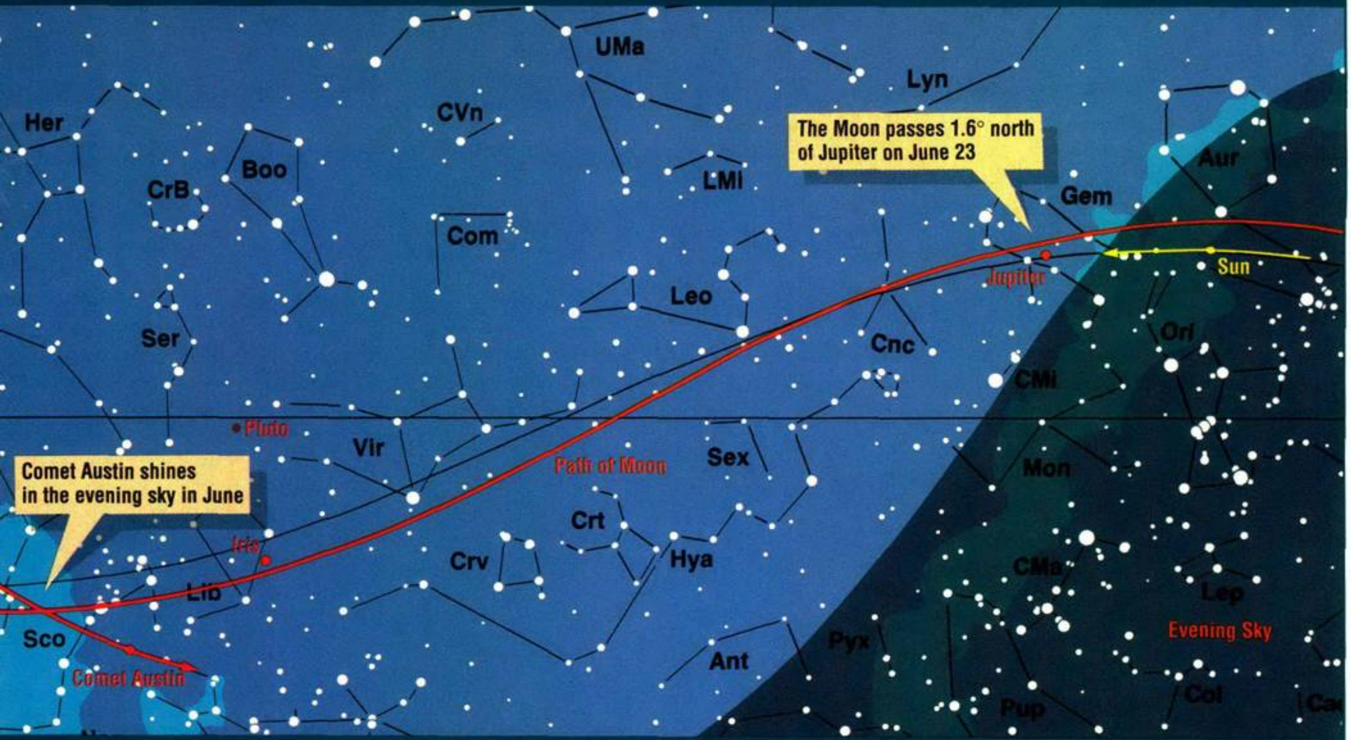
Uranus is at its brightest in June

Planet	MERCURY	MERCURY	VENUS	MARS
Date	June 1	June 15	June 15	June 15
Magnitude	+0.5	–0.5	–4.0	+0.4
Angular Size	8.1"	6.1"	13.3"	7.3"
Illumination	40%	70%	79%	86%
Distance (AU) from Earth	0.834	1.101	1.252	1.282
Distance (AU) from Sun	0.432	0.357	0.727	1.383
Right Ascension (2000.0)	2h58.2m	4h13.5m	3h05.7m	0h42.9m
Declination (2000.0)	13°16'	19°24'	15°24'	2°27'

Jupiter's Moons

Dots display positions of Galilean satellites at 3 UT on date shown. South is at top to match the view in a telescope.

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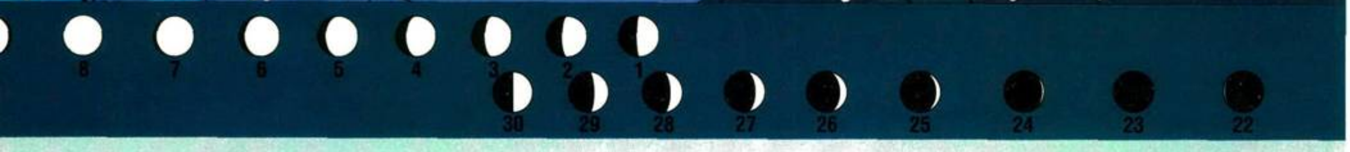
Lyn
Boo
CrB
LMi
Aur
Com
Gem
Jupiter
Sun
Leo
Ser
Cnc
Ori
CMi
Pluto
Vir
Sex
Path of Moon
Mon
Crt
Iris
Crv
Hya
CMa
Lep
Lib
Sco
Evening Sky
Ant
Pyx
Comet Austin
Pup
Col
Ca

The Moon passes 1.6° north of Jupiter on June 23

Comet Austin shines in the evening sky in June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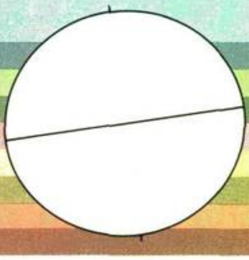
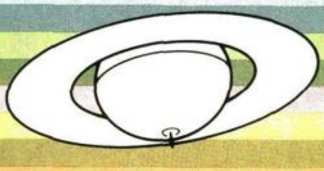
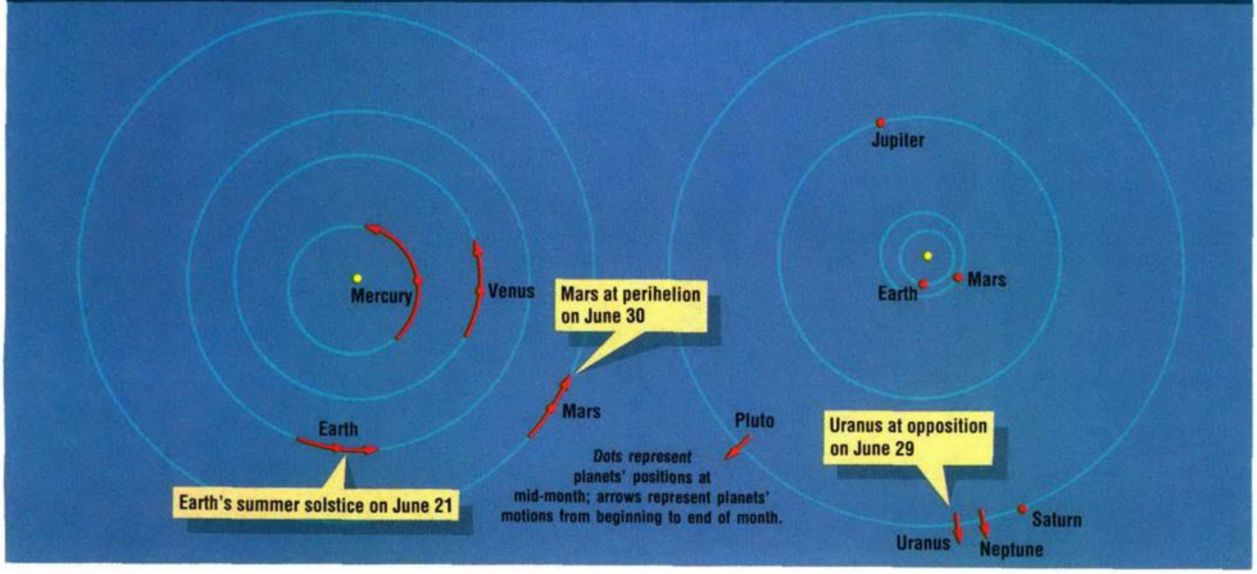




JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
June 15	June 15	June 15	June 15	June 15
−1.9	+0.2	+5.6	+7.9	+13.7
32.1"	18.1"	3.8"	2.3"	0.1"
100%	100%	100%	100%	100%
6.137	9.124	18.425	29.251	28.885
5.211	10.013	19.410	30.207	29.660
7h09.2m	19h44.2m	18h36.3m	18h59.8m	15h10.5m
22°41'	−21°10'	−23°30'	−21°51'	−1°17'

The Planets in Their Orbits


Mercury
Venus
Earth
Mars
Pluto
Jupiter
Earth
Mars
Uranus
Neptune
Saturn

Mars at perihelion on June 30

Earth's summer solstice on June 21

Uranus at opposition on June 29

Dots represent planets' positions at mid-month; arrows represent planets' motions from beginning to end of month.

ASTRONOMY Tests Four Medium-Aperture Refractors

The four 4-inch refractors we tested were all high-quality instruments that differed mainly in small details. All represent excellent values for the money.

by Robert Burnham

If there's one request we get that's reiterated in letter after letter from readers, it's this: "Will you *please* review medium-aperture refractors? I want to buy one and need to know which is best." Well, you asked for it, so here it is!

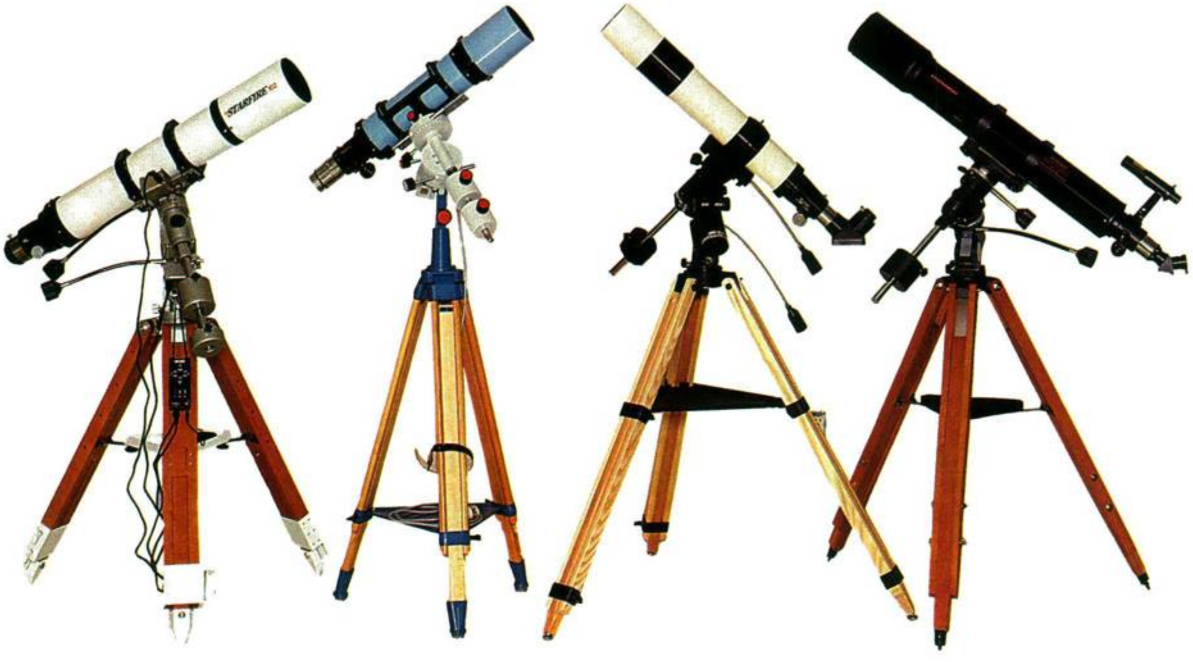
After examining telescopes in the 4-inch (100mm) aperture range, we settled on four that are widely available on an over-the-counter basis. The four we tested are the Astro-Physics 4-inch f/8 StarFire 102, the Celestron 4-inch f/8.8 SP-C102F, the TeleVue 4-inch f/5 Genesis, and the VERNONscope 94mm f/7 Brandon. You will find detailed specifications for the scopes and summaries of our test results on page 57.

To insure that we reviewed the same telescope you would buy, we ordered the Celestron and TeleVue scopes from a mail-order retailer, Shutan Camera and Video of Chicago. For lack of dealers, however, the Astro-Physics and VERNONscope instruments were purchased from their manufacturers. We were assured by both companies that the telescopes we received were picked at random from stock and are typical of current production runs. (We saw nothing in the course of our tests to lead us to suspect our review telescopes had been selected for better-than-average performance.)

Optical Performance

We tested the four telescopes indoors with an artificial star, first using a uniform magnification of 135x and then at higher powers selectively. We also used real stars outdoors, but bad weather and generally poor seeing conditions lent greater importance to the indoor tests, which yielded more impartial results.

We ranked the Celestron SP-C102F as the top performer, followed very closely by the Astro-Physics Starfire 102, the VERNONscope 94mm Brandon, and the TeleVue Genesis. When a star was in focus the Celestron gave clean images, perfectly free of excess color. Only the faintest hint of color (purplish white) was apparent when the star was thrown out of focus. At fo-



FOUR MEDIUM-APERTURE refractors take a bow. From left to right, they are the Astro-Physics 4-inch Starfire 102, the VERNONscope 94mm Brandon, the TeleVue 4-inch Genesis, and the Celestron 4-inch SP-C102F.

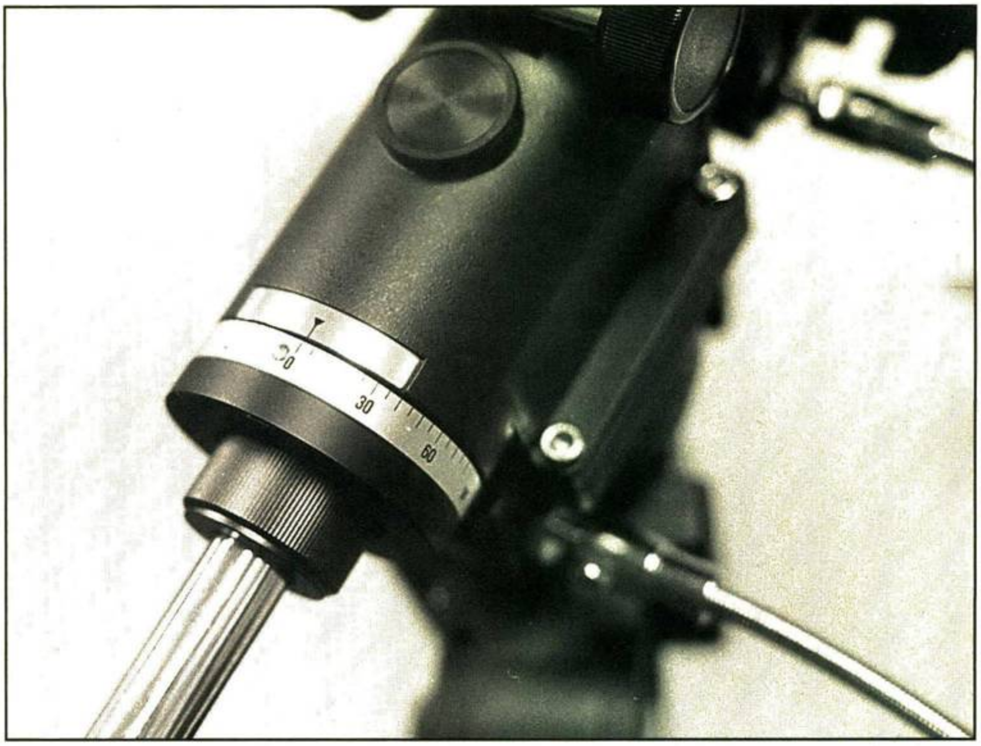
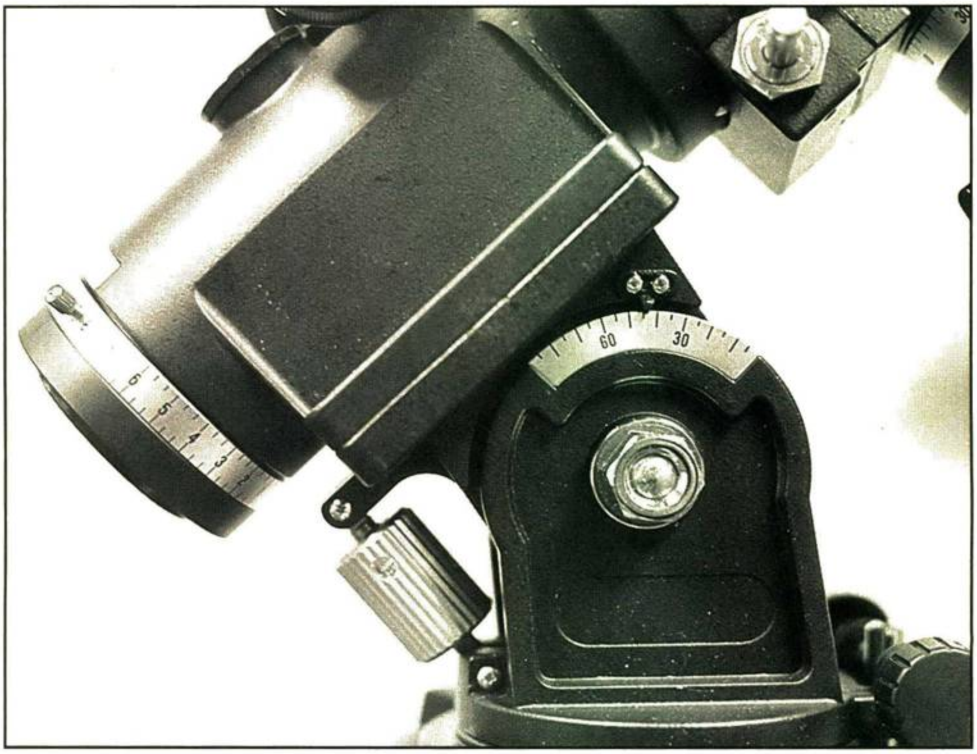
cus the Starfire was also color-free; when defocused, it was only very slightly colored. The 94mm Brandon gave a faint violet halo with a yellow-green disk tinged with red when inside focus, and a green ring with purple core when outside focus.

With the Genesis bright stars in focus had violet halos, larger and more noticeable than with the other telescopes. Defocusing a little produced a greenish disk with red fringe and a violet halo (inside focus) or a green ring with a purple center (outside focus). These color effects result from the telescope's short f/ratio, and in our view are an acceptable trade-off for anyone who wants a compact, convenient telescope. With this in mind, we felt the performance of the Genesis was excellent.

We also measured the difference between where violet and green light came to a focus for each telescope. (The smaller the difference, the more color-free the optics.) We viewed the artificial star through Edmund Scientific interference filters with central wavelengths at 4358 angstroms (violet) and 5461 angstroms (green). The differences, expressed as a percentage of the telescope's focal length, are: Celestron SP-C102F 0.015%, Astro-Physics Starfire 102 0.025%, VERNONscope 94mm Brandon 0.09%, and TeleVue Genesis 0.13%. Our measurements had an accuracy of ±0.01%. In judging the scopes' color performance, we noted that even the instrument with the greatest focus difference still performed as well as a high-quality f/15 doublet refractor of the same aperture.

None of the four telescopes showed significant errors of figure. Under critical examination, we found the SP-C102F's diffraction pattern was not quite identical on both sides of focus, indicating a very slight problem. (The rings were sharp-edged inside focus, a little soft outside.) This figure error was small enough, however, that few users would be likely to spot it under actual observing conditions. The Genesis had a slight amount of residual spherical aberration but not enough to impair its performance. The 94mm Brandon had a tiny degree of residual astigmatism that no amount of collimation tweaking could eliminate. It was detectable only when the image was put out of focus. Lastly, the Starfire appeared excellent even under very close scrutiny.

In summary, all four telescopes performed extremely well optically. Using our letter grade system (see page 56), we ranked the VERNONscope 94mm Brandon and the TeleVue Genesis as A– and gave both the Astro-Physics Starfire 102 and the Celestron SP-C102F an A.

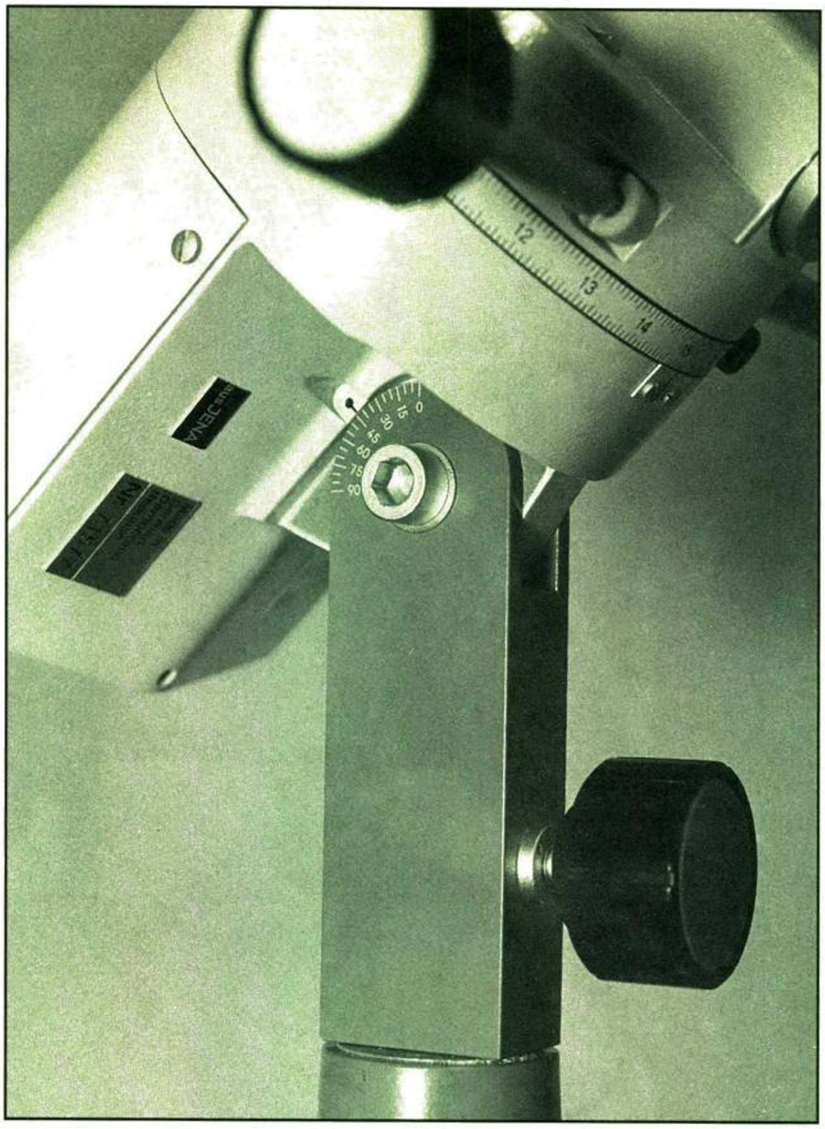



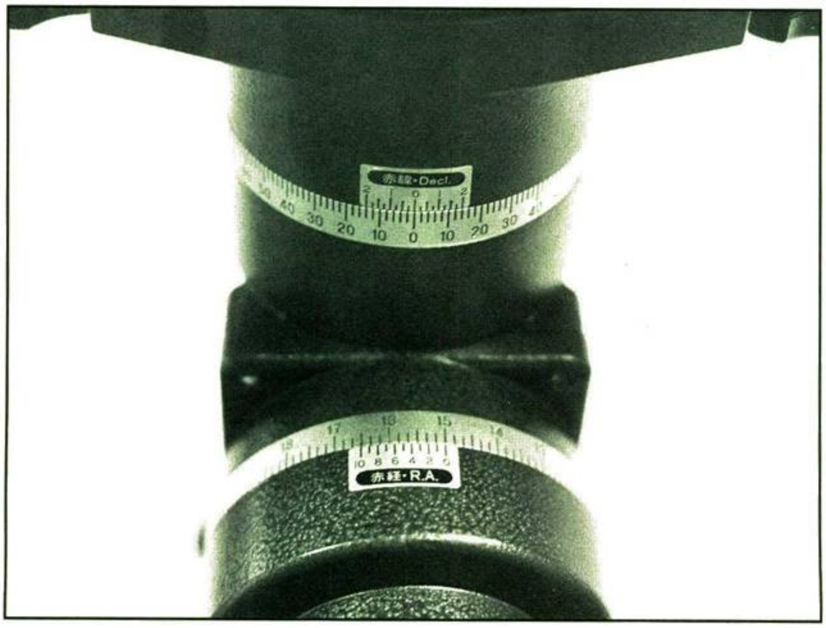
A SOLID MOUNTING comes with the TeleVue Genesis. Motions in both axes are manual. We felt the setting circles were too coarse to be practical.

Mechanical Performance

So much for the optics; now what about mechanics? To begin with the telescope tubes themselves, we found three of the telescopes come equipped to accept 2-inch barrel eyepieces, while the Celestron comes with a 1¼-inch barrel. The focuser action on each was smooth, and all had easy-to-grip focus knobs.

All the focusers have clamp mechanisms to lock onto an eyepiece or





THE TALL PIER on the aus Jena mounting (top) lacks fine polar alignment and azimuth adjustments. The Vixen mountings (above) offer vernier scales for more precise settings.

prevent a camera and adapter from sliding out, even with the scope pointed at the zenith. The Starfire has 4¼ inches of focus travel and an extender tube adds another 2 ½ inches. The SP-C102F has 3¼ inches' travel; the Genesis, 2⅜ inches; the 94mm Brandon, 2¼ inches (with a sliding drawtube adding another 7 inches). We found the focuser on the VERNONscope was not fully blackened inside, and with the drawtube extended we could notice a little scattered light in the image when a bright object lay near the edge of the field or just outside it. This reduced contrast a little and detracted slightly from the instrument's performance.

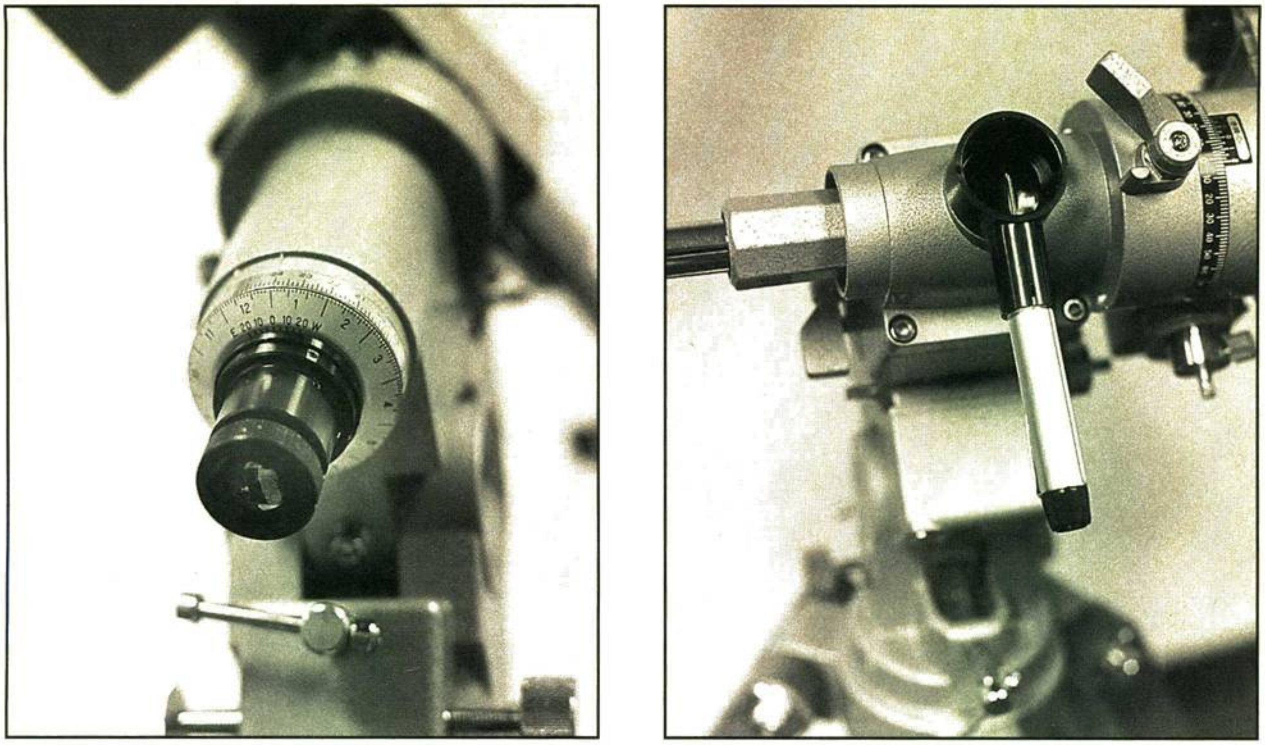
Dewcaps on all the telescopes are amply long, running 4½ to 6 inches. The dewcap on the Genesis is retractable and lets you screw the solid metal lens cap into threads on the front of the lens cell — a neat, tidy feature we liked.

Only the TeleVue and Celestron instruments come with star diagonals, although these are available as extras on the other two telescopes. We liked the way the light-absorbing threads on the inside of the TeleVue diagonal greatly cut down on scattered light. The Celestron diagonal uses an Amici prism and bends at 135° instead of the normal 90°. It gives an upright image, which is okay for terrestrial use, but the prism imparts an intrusive diffraction spike to all bright objects in the field of view. We think astronomical users would prefer a standard 90° diagonal.

The Celestron and the Astro-Physics instruments both have ¼-20 tapped holes in the tube-mounting rings. This handy feature lets you attach a camera easily for piggybacking, a nice touch every astrophotographer will appreciate.

The telescope mountings, all German equatorials in design, differed in their "feel." Celestron provides a standard Super Polaris mounting for the SP-C102F and Astro-Physics has a Super Polaris DX heavy-duty model. Both are made by Vixen, a Japanese manufacturer. The Genesis comes on the TeleVue Equatorial Systems mount, a Japanese import. And the VERNONscope 94mm Brandon has a Telementor equatorial from aus Jena, the U.S. brand name for products made by VEB Zeiss of Jena, East Germany. The DX and aus Jena mountings have drive motors; the other two do not, although they are available as extras. The DX also *includes a drive on its declination* axis.

The equatorial heads of all the



A POLAR-AIMING TELESCOPE is built into the Vixen Super Polaris mountings, both ordinary and DX models. The dial (left) sets your longitude, and a special penlight (right) illuminates the polar reticle with red light and also detaches to help you read charts.

scopes are large and solid, with the TeleVue mounting noticeably larger and sturdier than the rest. All mountings have setting circles and latitude scales, although they differ as to the markings. The Astro-Physics Super Polaris DX mount has 2° intervals on the latitude and declination scales, 10m on right ascension. Verniers let you read down to 15' (dec.) and 1m (r.a.). The ordinary Super Polaris with the Celestron scope has the same markings. We felt that the setting circle scales on the TeleVue Systems mount — 5° intervals in latitude and declination and 20m in right ascension — are too coarse. The aus Jena mount from VERNONscope has polar elevation markings at 5° intervals, declination at 1°, and right ascension at 5m. Since it is not equipped with verniers, these are all too coarse to be of much help. If you consider setting circles to be an important accessory, then this could influence your purchase.

On the TeleVue mount we found that the Allen wrench provided would not fit the bolts that attach the saddle plate to the tube ring. Also, the saddle plate fits onto the equatorial head in only one way, but there is no marking on either piece to help you find the right orientation.

Three of the four mountings have easily used polar altitude and azimuth fine adjustments that could be minutely changed and then locked in place. The aus Jena mounting, however, has just a simple bolt that you loosen and tighten (for altitude) and a thumb knob (for azimuth). Alone among the mountings the aus Jena converts into an altazimuth by setting the latitude to 90°. Both Vixen mountings have identical built-in polar boresight telescopes with a reticle that made alignment fast and easy using Polaris.

Incidentally, the instructions in Vixen's booklet for setting the boresight to your longitude tell you, incorrectly, to set the dial to the east whether you live east or west of your standard time meridian. (You should set it west if you live west.) Astro-Physics includes a separate sheet with their DX detailing another method that avoids the longitude question.

With the Vixen mountings the polar alignment given by the boresight is good enough for observing and piggyback astrophotography, but anyone doing long-exposure photography through the main telescope should fine tune the alignment with the star drift method. The polar axis on the TeleVue mounting accepts a boresight telescope, an option that lists for $140. Without it you simply peer up though the hole for a rough alignment on Polaris or use the star

How Steady Are They?

	Retracted		Extended	
Mountings	**Bare**	**S-E**	**Bare**	**S-E**
Super Polaris DX (Astro-Physics)	3.5	1.5	4	2
Super Polaris (Celestron)	2.5	1	4.5	2
Equatorial Systems (TeleVue)	1.3	1	1.5	1.5
aus Jena (VERNONscope)	2	1.5	3	2

Figures give the average time in seconds for all vibration visible at 135x to die out after a light tap on the tube. Tripod legs were retracted or extended as far as possible. "Bare" means with tripod tips used as is; "S-E" means with Shake-Enders.

Our Optics Rating System

We grade telescope optics from "A" (best) to "E" (worst) according to the following standards:

An "A" rating means the telescope shows stellar images that closely approximate a perfect Airy disk. An "A–" means that the optics are diffraction limited, but a critical eye can discern slight defects.

A "B" rating means that stellar images have no more than twice the area (1.4 times the diameter) of the Airy disk.

A "C" rating means the optics give a stellar blur circle that has twice the diameter of the Airy disk. Some figure errors may also be visible, as well as errors attributable to faulty assembly or optics that are deformed by their mounting cell. In our opinion a "C" is the lowest rating acceptable.

A "D" rating means the scope has a larger blur circle and/or more pronounced figure errors.

An "E" rating means the telescope has optics that are practically unusable.

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drift technique. The aus Jena mounting has no boresight or provision for one, so one uses either a rough-and-ready eyeball alignment (which usually suffices for general observing) or the star drift method.

Each of the four mountings has smooth slow motions and locks that tighten nicely. The aus Jena and Vixen mountings were tight on clearances for the locks if you are wearing gloves, but they are workable. The TeleVue also had a small but acceptable amount of backlash or "deadband" in the right ascension motion.

The motor drives on the two telescopes equipped with them both performed well. The aus Jena comes with 10 feet of three-prong (grounded) cord; there is no on/off switch, so you simply plug it in and pull it out. The drive performed nicely, tracking steadily for half an hour and keeping Jupiter centered in a 175x field of view.

The Super Polaris DX runs on six C cells or an AC adapter (not provided). Its control paddle fits the hand comfortably and is easy to use. The drive motors on both axes will slew at 2x and 16x the sidereal rate. As we slewed in declination, we noted a one-second delay in movement when we switched direction, but there was an immediate response when we continued in the same direction as the last command. No such deadband was apparent in the right ascension motion, and tracking was smooth and steady.

We gave the TeleVue mounting top marks for shake-damping, followed by the aus Jena, Super Polaris, and the Super Polaris DX. We were disappointed that the best optics — Celestron's — did not come on the best mounting. The aus Jena mounting stands quite slender compared to the squatty tripods of the others (see photo on page 52). This may be more a psychological than a mechanical concern, but we found it hard to relax completely around a tripod that looked so tippy. (We judged it would be fairly simple to make a larger spreader out of ¾" plywood and to adapt some common hardware to attach it.)

We tested the mountings' ability to shed vibrational energy by tapping on the tube while viewing at 135x, and averaging the time (in seconds) that it took for the vibrations to die away. The results appear on page 55. Notice that all mountings performed better with their legs fully retracted, although at times this may force the observer into awkward positions (see below). Note also that even good mountings benefit from a set of Shake-Enders under the tripod tips.

We liked the spreader used on the TeleVue mounting to hold the tripod legs firmly apart. On the Vixen mounts, the spreaders did not fasten to the tripod legs tightly. We wondered how much this was responsible for these mountings' somewhat lesser stability relative to the TeleVue. Although we could erect the tripod and pull outward slightly to put each leg under tension, this felt makeshift. On the aus Jena mounting the spreader did not bolt very tightly to the legs. It could pop loose suddenly if the mounting were tilted much away from the vertical.

In pointing any of these scopes at or near the zenith with the legs retracted for greatest stability, observing may become awkward (even with a star diagonal) because the eyepiece is close to the ground. We noted for the Astro-Physics scope this "zenith eyepiece height" was 22 inches (with the legs retracted) and 30 inches (extended). For the others the numbers were: Celestron 16 and 33 inches, TeleVue 30 and 39 inches, and VERNONscope 33 and 54 inches. We found a 3' x 5' piece of thick indoor/outdoor carpet remnant let us kneel or lie on the ground relatively comfortably to look into a low-placed eyepiece. Nonetheless, the 16-inch elevation for the ordinary Super Polaris was quite low, even when using a diagonal.

The scopes span a range in weight when assembled for observing: 65 pounds (Astro-Physics), 47 pounds (TeleVue), 44 pounds (VERNONscope), and 36 pounds (Celestron). The Astro-Physics scope approaches the upper limit of what most people can carry easily, and none of the scopes could be described as light.

How easily could a total beginner assemble and set up these scopes? Fairly easily, all in all, but in our opinion it isn't quite as easy as it could be. Celestron and Astro-Physics supply the exact same Vixen manual to explain both Super Polaris mountings. Celestron also provides a short booklet that covers their Firstscope 80, SP-C80, and SP-C102 instruments as well as the SP-C102F. This latter booklet is adequately detailed and contains a short guide to astronomy. Vixen's manual for the Super Polaris is fully illustrated and should be read carefully. We noted, however, that the photos and drawings show a mount slightly different from what the buyer gets. For example, the ordinary Super Polaris that is illustrated has a different declination vernier than the current model, and the DX version of the mount is not illustrated at all. Astro-Physics told us that they were developing a manual to include with every DX they sell, but the new manual was not available at the time we went to press.

The instructions packed with the aus Jena mounting describe a 63mm f/13.3 Telementor refractor on the unpowered version of the mounting we received. This error apparently originated at the factory. We were able to figure out the differences and set the mounting up correctly, however. TeleVue provides clear assembly instructions, but again we noted some design variations have been introduced since the manual's illustrations were prepared. Moreover, they do not explain or illustrate how to put a Genesis telescope on the mounting (which is mainly sold with

Astro-Physics 4-inch StarFire 102

A 4-inch f/8 refractor, supplied with 2.7-inch diameter focuser, adapters for 2-inch and 1¼-inch eyepieces, and a carrying case. Includes a Vixen Super Polaris DX equatorial mounting, polar alignment scope, drive motors on both axes, battery pack, control paddle, and assembly wrenches.

Manufacturer: Astro-Physics, 7470 Forest Hills Road, Loves Park, IL 61111; (815) 282-1513.

List Price: $1,565 (telescope); $1,245 (mounting). We paid $2,948 total.

Pros: Superb optics; large-diameter focuser lets image fill medium-format film frame; mounting is enjoyable to use.

Cons: Low eyepiece height at zenith; f/8 is relatively slow photographically; no finder scope included.

Summary: Excellent telescope.

Celestron SP-C102F

A 4-inch f/8.8 fluorite refractor, supplied with 26mm Plössl 1¼-inch eyepiece, and a 6x25 finder scope. Includes Vixen Super Polaris equatorial mounting, polar alignment scope, and assembly wrench kit.

Manufacturer: Celestron International, 2835 Columbia Street, Torrance, CA 90503; (213) 328-9560.

List Price: $4,118 (telescope and mounting). We paid $2,369.

Pros: Excellent color-free images.

Cons: Low eyepiece height at zenith; slow optics.

Summary: Best optics of the four.

TeleVue Genesis

A 4-inch f/5 refractor, supplied with 26mm Plössl 1¼-inch eyepiece, 2-inch diagonal, 2-inch to 1¼-inch eyepiece adapter, and carrying case. Includes a TeleVue Equatorial Systems mount and assembly wrenches.

Manufacturer: TeleVue, 20 Dexter Plaza, Pearl River, NY 10965; (914) 735-4044.

List Price: $2,195 (telescope); $1,140 (mounting). We paid $2,278 total.

Pros: Fast f/5 optics are excellent for low-power sweeping and photography.

Cons: Small amount of visible color in images; needs Barlow for high powers; no finder scope available.

Summary: Very fine compact scope on an exceptionally steady mounting.

VERNONscope 94mm f/7 Brandon

A 94mm f/7 refractor, supplied with 2-inch focuser. Includes an aus Jena Telementor equatorial mounting, right ascension drive, and assembly wrench.

Manufacturer: VERNONscope & Co., 5 Ithaca Road, Candor, NY 13743; (607) 659-7000.

List Price: $1,495 (telescope); $995 (mounting). We paid $1,784 total (spring sale price).

Pros: Focal length is a good compromise between low-power star field viewing and high-power planetary viewing.

Cons: Slender tripod offers no fine adjustments in polar altitude or azimuth.

Summary: Excellent optics in a midrange focal length.

the Renaissance model).

In general, we felt that with a telescope costing over $2,000, the owner's manual should be complete and accurate. Although we didn't encounter major problems in assembly, we feel no buyer should ever have to interpret assembly instructions. Everything should be shown *exactly* as the buyer will find it, even if this requires repetitive or redundant sections, or frequently updated manuals.

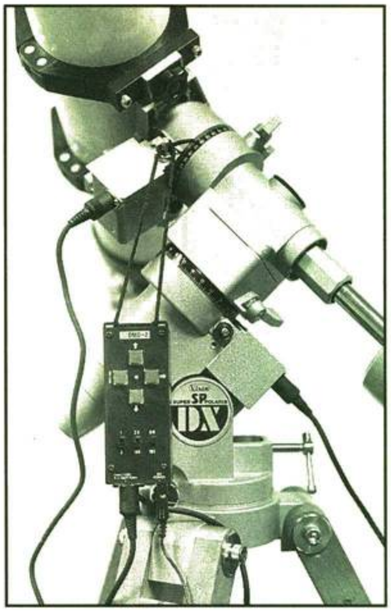
What about packaging and transport? All the scopes arrived collimated, in perfect condition, with no damage. We were pleased to see that TeleVue and Astro-Physics provided carrying cases for their telescope tubes. The cases were strongly constructed, nestling the scopes in finger-foam, and had conveniently placed carry handles. The Celestron and VERNONscope telescopes, and all of the mountings, came in cardboard boxes insulated from bumps with styrofoam. We suspected these boxes would break down rapidly under constant field use, so they are really for shipment or long-term storage only. (A packing diagram would be helpful, and it would also orient beginners to the names of the parts.)

Who's the Overall Winner?

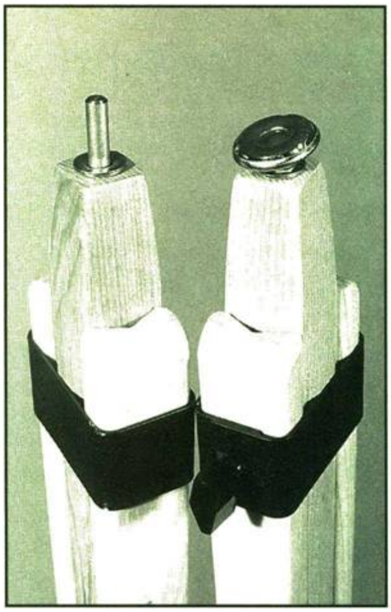
Which telescope is best? That's really hard to say and depends largely on the preferences of the observer. The Celestron SP-C102F is as color-free as any refractor we've ever seen, the Genesis is super-portable, and the Astro-Physics Starfire 102 has an extralarge diameter focuser. The VERNONscope 94mm Brandon represents an excellent compromise between fast optics and a "planetary" focal length. The TeleVue mounting was the beefiest and steadiest we tested.

When we first decided to review these four telescopes we wondered if we'd be able to point out an overall "best telescope." This has indeed proven difficult because the very best optics didn't come with the very best mounting. Optically, the Celestron was tops (although not by very much) and the easiest mounting to use came down to a toss up between the unpowered TeleVue and the motor-driven DX.

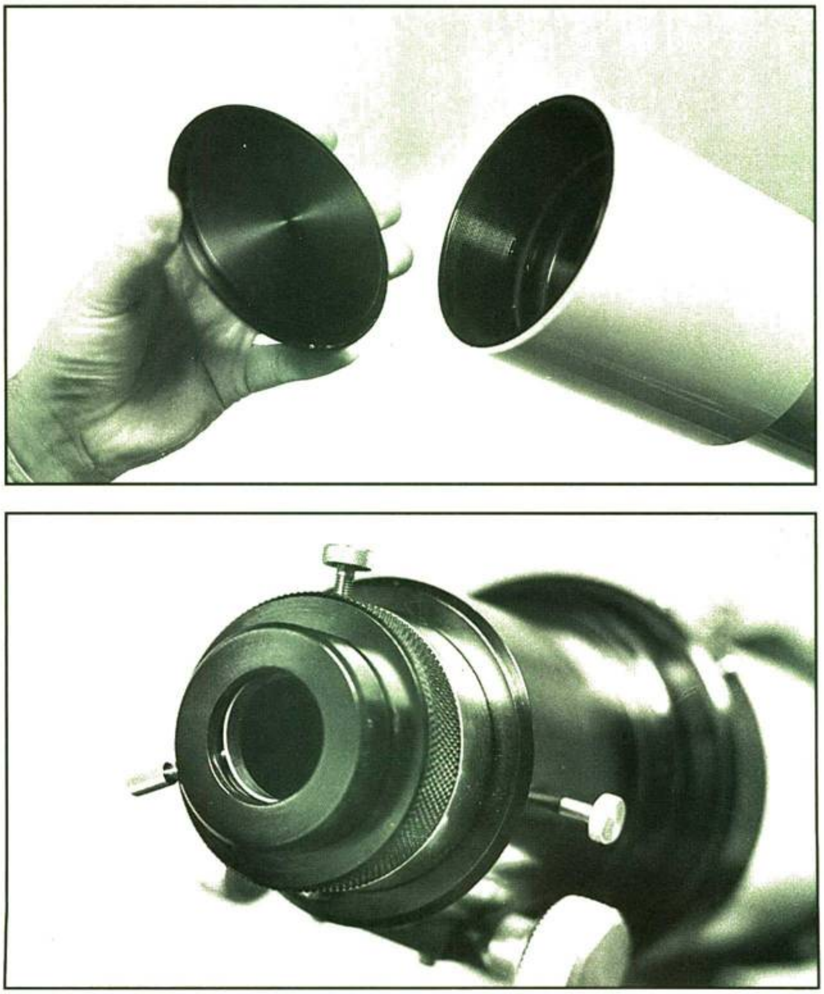
All in all, however, we felt that these four telescopes offer excellent value for the money. Which one is best for you depends on how you value such matters as focal length, focal ratio, ease of medium-format astrophotography, or total weight. We can recommend every one of these four telescopes without hesitation. □



A HAND CONTROLLER, battery pack, and motors on both axes make the Vixen DX easy to use.



TWO KINDS OF TRIPOD TIPS enhance the versatility of the TeleVue Systems mounting.



A BEAUTIFULLY MACHINED lens cap and a retractable dewcap are good features of the Genesis (top). The Astro-Physics Starfire has an excellent eyepiece lock that grips the barrel without marring it.

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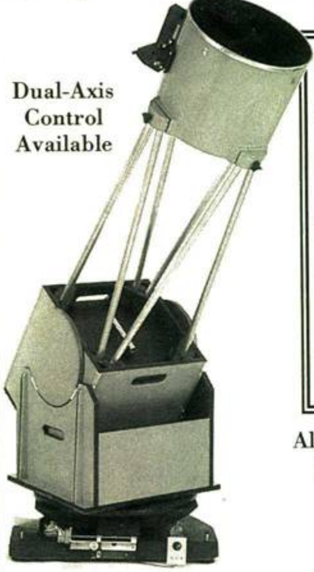

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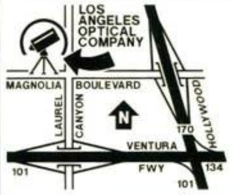

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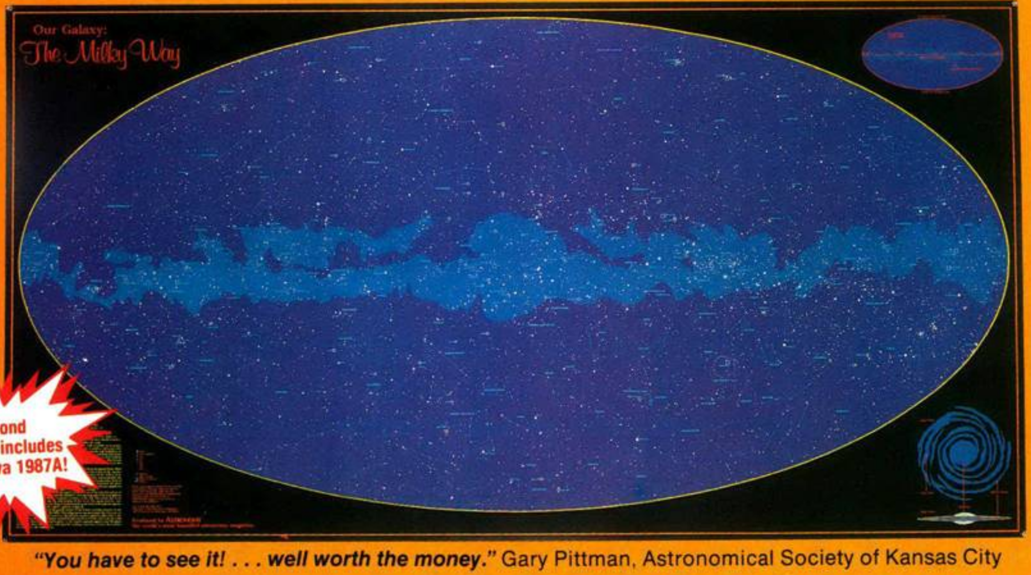

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Get Ready for Weekend Observing

The key to successful dark-sky observing is getting everything you'll need to the right place at the right time.

by Steve Coe

Come the dark of the Moon, something primordial stirs inside every observer. Deep down a great force screams, "Let me have dark skies!" Your body tenses, adrenaline flows, and your pupils dilate. Mountains, deserts, forests — here I come!

In that primitive fantasy, you load an enormous telescope into your jacked-up pickup, manfully toss a few old blankets in for warmth, and pack along a gunnysack of grub. You drive off into the sunset toward that perfect black-sky site.

Reality intrudes. You arrive at the site, but you have no eyepieces. You left your warm jacket at home, and there's frost on the ground. Oops — your spare tire is flat. You drop your car keys and can't find them. It happens to the best of us. I've learned the hard way that successful backcountry weekend observing takes serious planning.

You must first decide where to go. To do that you need a good map, one that shows small towns, back roads, and parks. Government topographic maps are great. Study your maps and talk to local amateurs who know the area.

Now any reasonable person might think that national and state parks are ready-made for astronomy. At least, I once did. When my friends and I arrived at a park after a two-hour drive, our observing site at the park was submerged in a sea of humanity. There wasn't room to set up a pup tent. Any park that's well-known is going to be popular, especially when the weather is good.

But crowding may be the least of your worries. In the hunting season lots of people are out in the woods. Be careful! Put up with some lights from fires and camp lanterns. You don't want to be mistaken for pronghorned antelope.

In the off-season look for small parks that don't draw crowds, or for out-of-the-way places where there is little traffic. Tell the park ranger that you plan to set up telescopes. If you find a promising site on private land,

ask the owner for permission to spend a night there. The last thing you want is a load of buckshot in your primary mirror.

You may also encounter outdoor parties. On several occasions, I have been bothered by carloads of teenagers driving by with headlights ablaze. If there is too much party traffic at your observing site, find a new location.

Don't drive to a new area on New Moon Saturday night and expect to stumble on a good location. Check out the site in advance (that's what Third Quarter Moon is all about) or arrive two hours before sunset and scout the area before darkness falls.

Because you will be driving late at night on back roads, routine precautions are in order. Head out with a full tank of gas. Make certain that the spare tire is in good condition. Check that it's inflated or carry an inflation device. Always carry several quarts of oil and five gallons of water or anti-freeze for the radiator. If you drive an older vehicle a spare fan belt and fuses could make a big difference in what time you get home. Don't forget duct tape, either. It can be used for a variety of purposes, such as repairing a leaking radiator hose. In the winter having a set of jumper cables, road flares, a blanket, shovel, and a first-aid kit could save your life.

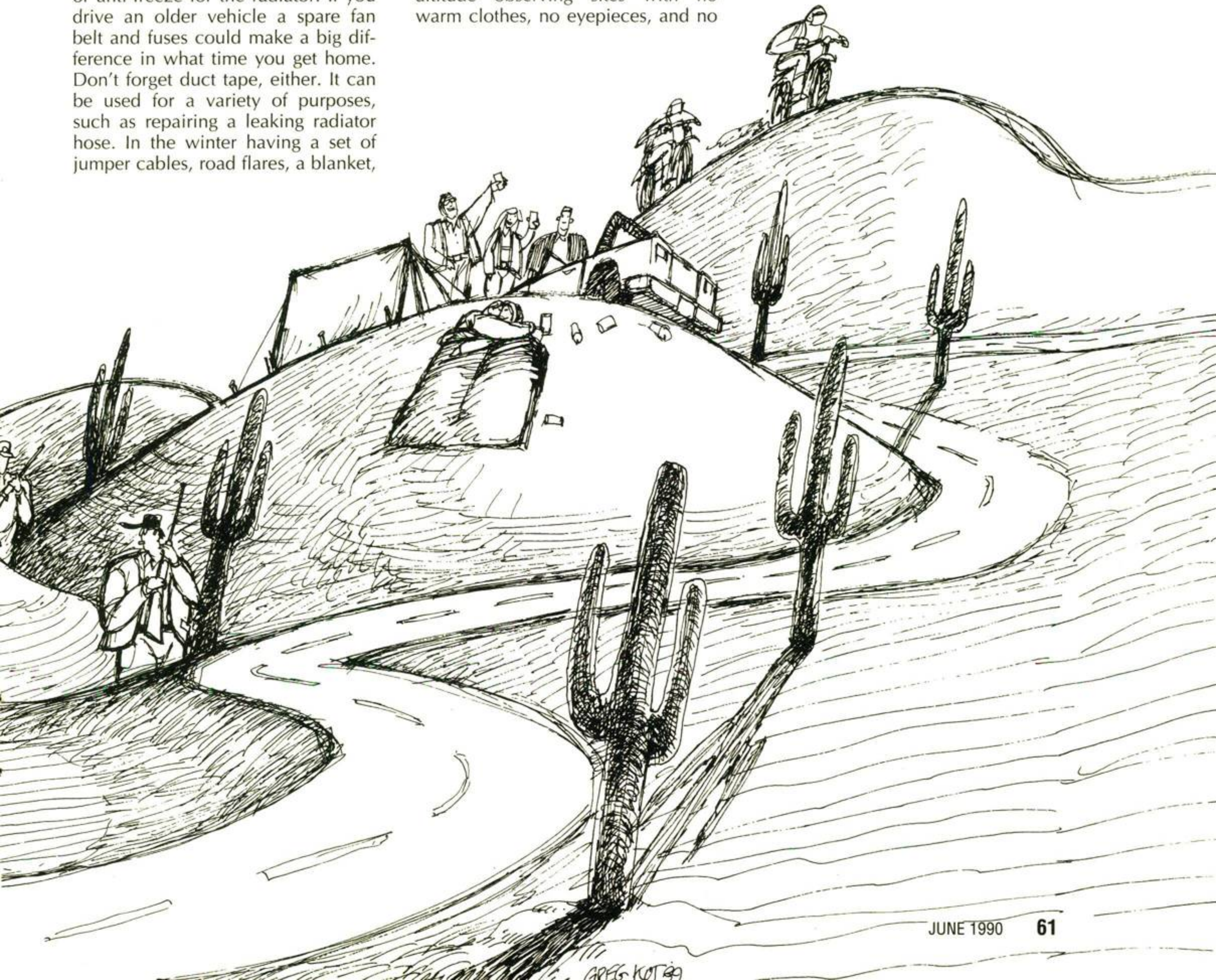
If you observe with friends and drive to your site in separate vehicles, a CB radio will make the trip safer and seem faster. Radio chatter also helps to keep everyone awake during the trip home late at night, a time when more than a few fearless observers have fallen asleep at the wheel. Choose a channel away from the large volume of radio traffic on Channels 19 or 21. CB radios are cheap these days. For less than the price of an eyepiece you can tell all your buddies what you observed that evening while it is still fresh in your mind.

Finding an observing site is a great accomplishment but what did you bring with you for observing? Good, you remembered the telescope. What else did you bring? You'd better check — and you'd best do it before you leave home.

I've had friends arrive at high-altitude observing sites with no warm clothes, no eyepieces, and no drive corrector. On one expedition to the White Mountains of Arizona, a long way from home, my buddy Pierre Schwaar discovered he had forgotten his counterweight. I watched as a master telescope builder taped a large rock to the declination shaft of his telescope.

Bring plenty of warm clothes. Ski suits provide full body coverage and don't have gaps that let your back or neck get cold. Use a muffler, mask, and ski cap to keep your head warm. Warm socks and Moon Boots really keep your feet warm.

Don't forget your stock of dedicated telescope hardware. Fill a small toolbox with tools to fit every nut and bolt on the telescope, and bring along plenty of spare nuts and bolts. Wait until the hardware store has a sale and buy one of every tool you use for observing. Spray these



tools with white paint so they are easier to find when you drop them.

You'll need to protect your telescope if the weather turns bad. Keep a large plastic garbage bag in the box with your tools along with twine or elastic cords to secure the bag. If you are going to be at one location for several days nothing beats these cheap and expendable covers.

And fellas and gals, take it from me, you don't want to forget your eyepieces. An afternoon building a box large enough to hold eyepieces, star charts, paper, pencils, and other observing essentials could save you a lot of grief. Use the same box when you observe at home, and keep it stocked and ready to go.

Astrophotographers have to remember to bring an enormous number of things. A special box for camera bodies, film, focus gadgets, guiding gadgets, shutter release cables, and spare batteries is a must. Put in everything you use and keep it there so you won't arrive miles from home missing something vital.

Oh yes, bring an extra red flashlight and spare batteries. Few things can stop a great observing session faster than a dead flashlight. I put a piece of masking tape over the end of the light to dull the flashlight's glow when the batteries are new, then peel it back bit by bit as the batteries weaken. A loop of string lets me hang the flashlight around my neck and prevents me from losing it. What are you going to use in the dark to find a missing flashlight?

While you're observing, be kind to yourself. Take a break every couple of hours. Get off your feet. If you've been sitting, get up and walk around. Stretch a bit. Chat with other folks, look for meteors, or learn an obscure constellation. A snack will help keep you awake and will give you energy to fight off the cold. No, the snack need not be a Milky Way bar.

Last, but not least, don't forget your observing notebook. Once you've seen that celestial gem, don't lose the observation. Many of my notes from when I was getting started are something cryptic like "Wow" or "Not much." If you took the time to find it, at least document that with some description of the object. A small tape recorder is easier than written notes but make certain you transcribe your observations into your notebook before you use the tape again.

One final bit of advice: *Make a list of things to take with you while observing.* If you leave vital equipment at home then all this advice is not very useful. I've tacked my list on the wall of the garage. Each time I go observing I check off each item as I put it in the pickup. Since I started using this pack-up list I have not forgotten anything important. Learning the hard way does have its rewards. □

Steve Coe is an active observer, a member of the Saguaro Astronomy Club, and a sponsor of that group's Arizona Database project.

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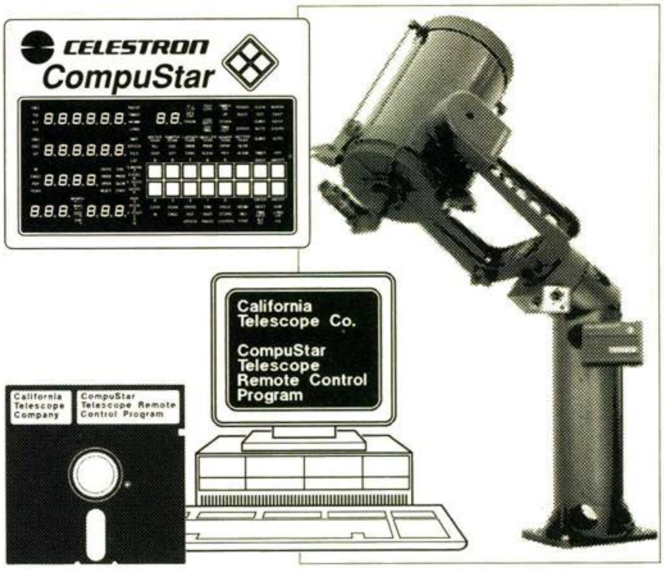
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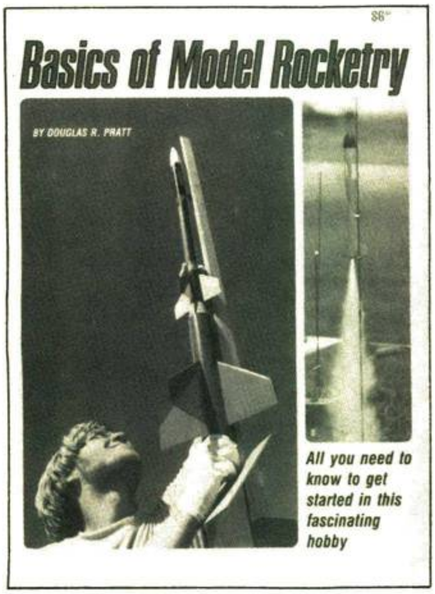
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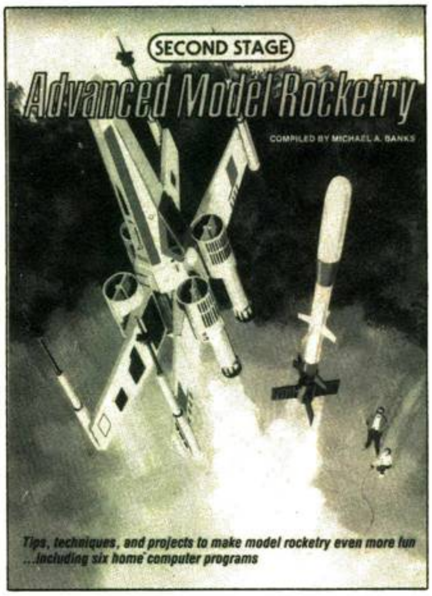
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Observing Nebulosities in Cygnus

Challenge yourself to spot the North America Nebula, the Veil, and the elusive clouds that envelop Gamma Cygni.

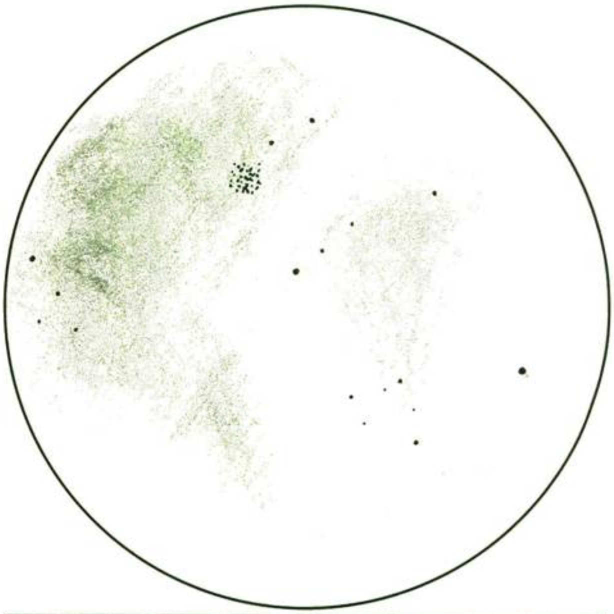
by Alan Goldstein

When you stand under the stars on a cool spring night, the rich starry realm of Cygnus the Swan lies overhead. The charm of Cygnus is simple: The Milky Way's shimmering path cuts directly through the constellation and, laced with dark voids and holes, connects it with Aquila to the south and Cepheus to the north. Cygnus, smack in the center of the northern Milky Way, is loaded with rich star fields, colorful double stars, open clusters, and nebulae of all shapes and sizes. But of all the riches of Cygnus the most alluring is its unique collection of nebulae. Nowhere else, not even in Sagittarius, do observers get the chance to see such a varied and unusual collection of glowing clouds of gas.

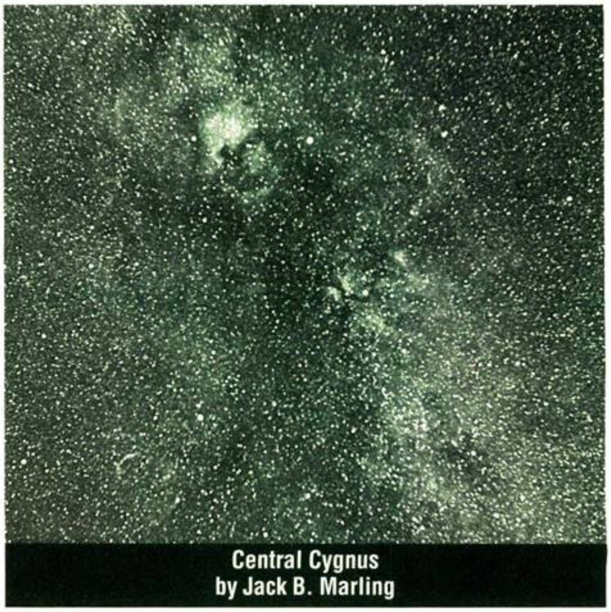
The largest and brightest nebula in Cygnus is the **North America Nebula** (NGC 7000). The object's curious nickname arose in the late nineteenth-century when German astronomer Max Wolf photographed this object and examined it carefully on a series of plates. NGC 7000 gets its shape from several large areas of dark nebulosity that surround it and obscure part of its face. This dark nebulosity creates several remarkable features similar to North American geography: The Gulf of Mexico, the Atlantic and Pacific oceans, Hudson Bay, and even Florida.

All of these features are distinctly visible on photographs made even with simple equipment, but observing them is somewhat more difficult. On dark, transparent nights the North America Nebula is visible to the naked eye and appears like an enormous bright glow southeast of Deneb, the brightest star in Cygnus. To the naked eye the shape of North America is somewhat recognizable, although not easily. However, under the same dark, transparent sky, low-power brings the nebula into sharp relief and shows the surrounding field crammed with bright stars.

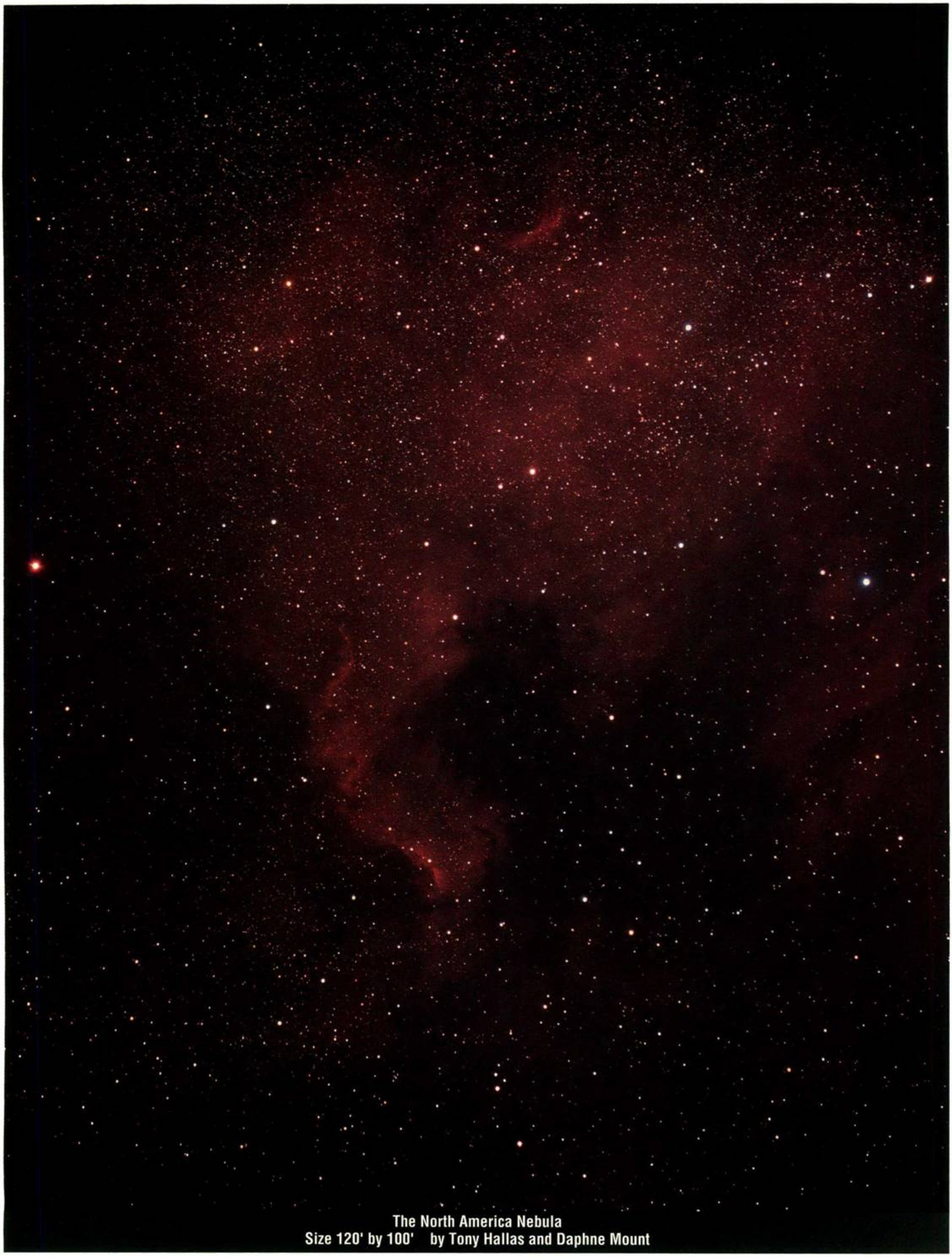
A 3- or 4-inch telescope or large binoculars yields the best views of the North America Nebula because they provide modest magnification, a wide field of view, and good contrast. Larger rich-field instruments do not work as well as you'd think. While they show fainter stars, the field of view becomes narrower, the contrast of the nebula against the background Milky Way diminishes, and the great nebula becomes less impressive. The optimum field of view is about 3°, since the nebula is about one and a half degrees across. The reddish color visible in photos is not visible to the eye; visual observers see the nebula as gray-



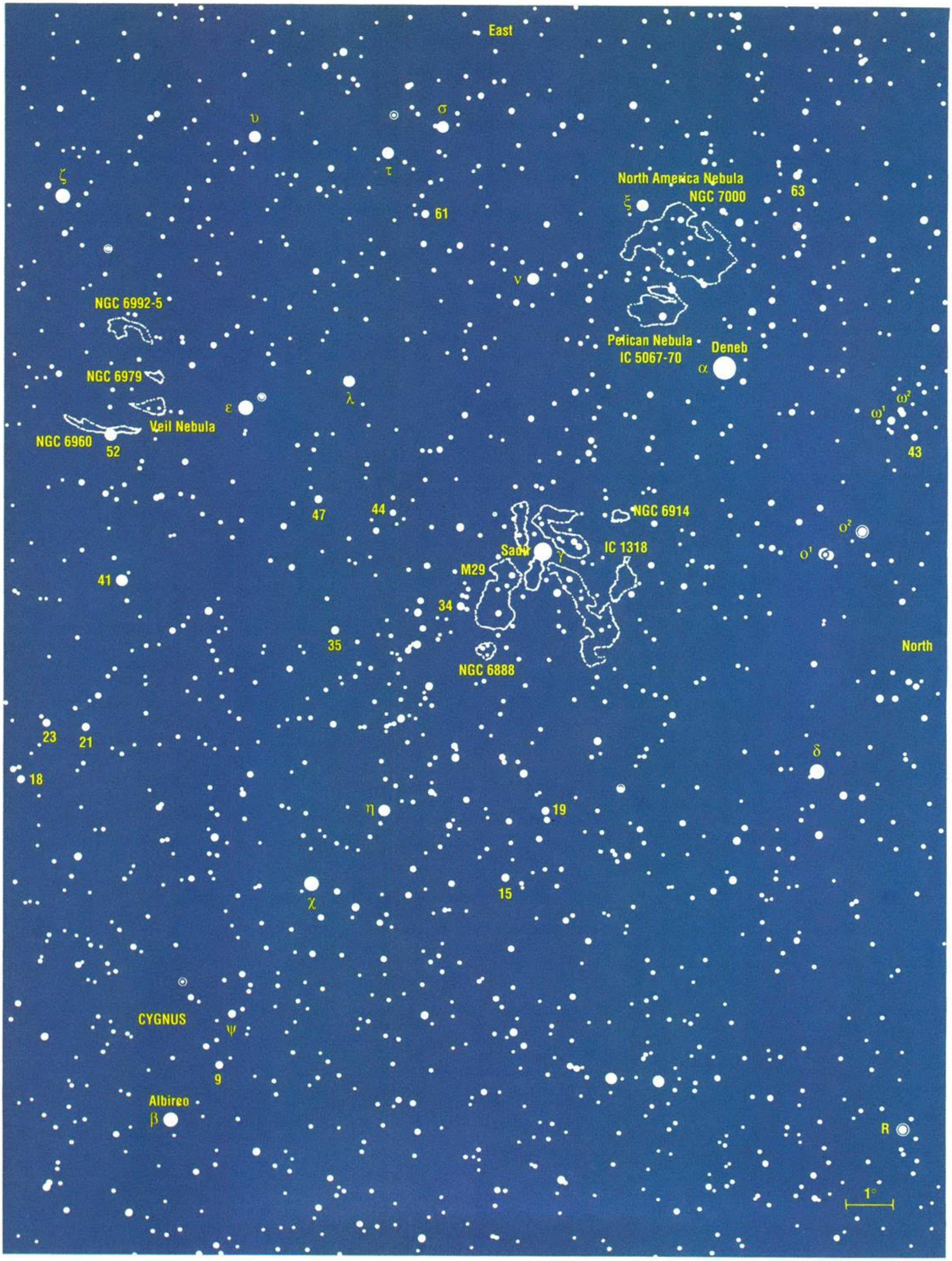
The North America Nebula
12.5-inch f/4.5 scope at 35x and 150x by Jeff Corder



Central Cygnus
by Jack B. Marling



The North America Nebula
Size 120' by 100' by Tony Hallas and Daphne Mount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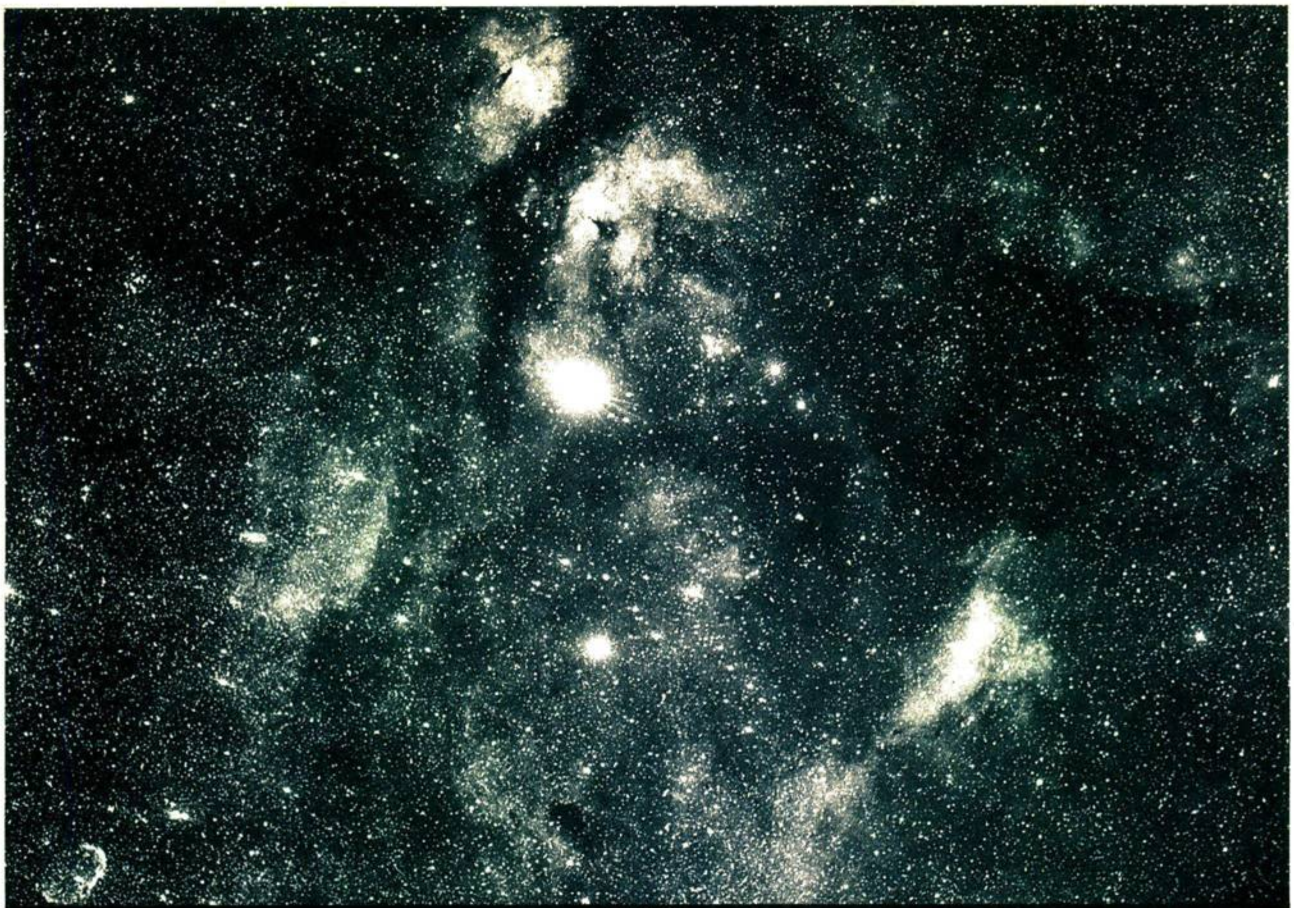
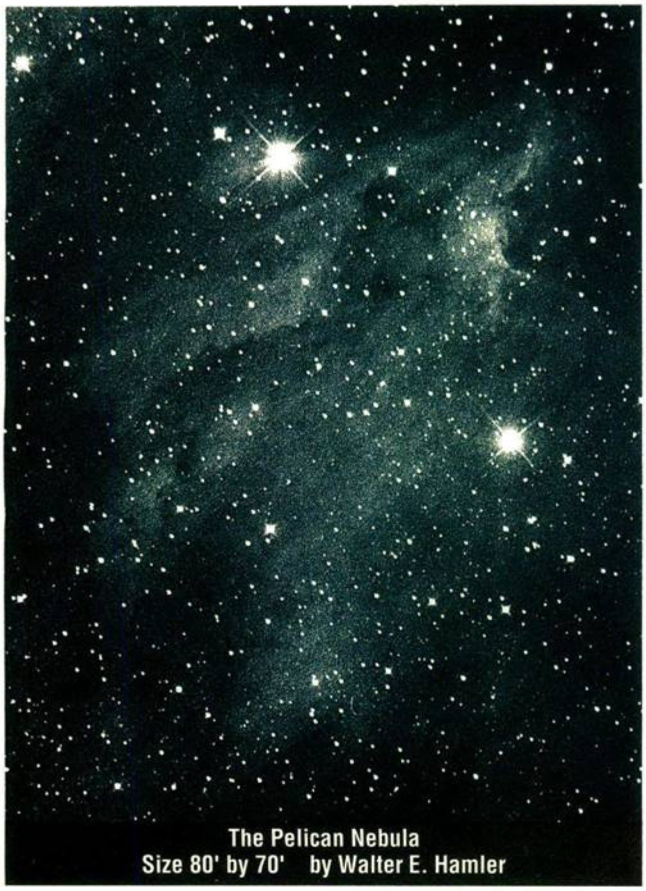


IC 1318
by Brant Nelson



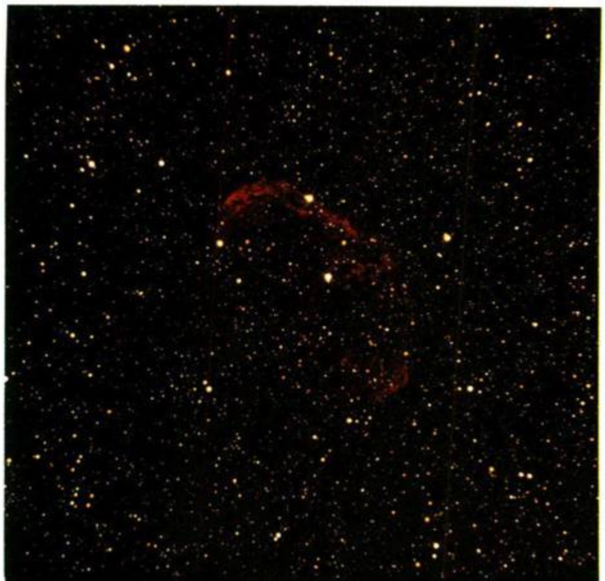
The Pelican Nebula
Size 80' by 70' by Walter E. Hamler

green. The most distinctive identifying features of the North America Nebula are the "Gulf of Mexico" and a dark, ring-shaped feature just south of "Hudson Bay." The stars inside the ring form a pattern that resembles a smiling face. Can you see this feature in your telescope?

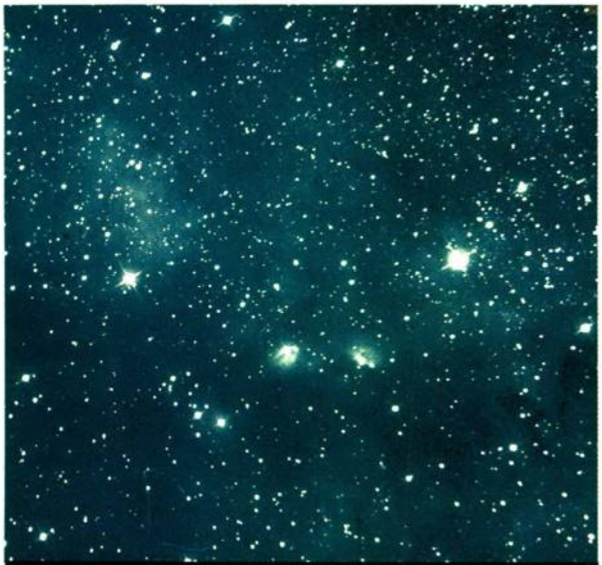
Just west of the North America Nebula, about where Bermuda would be, lies the much fainter emission nebula called the **Pelican Nebula** (IC 5067-70). Its complex shape really does resemble a pelican, but only in photographs. Visually the object is difficult to see and appears as a large, oval glow with its brightest parts forming odd, curving shapes. Look for the gap in the pelican's lower bill and the bird's eye. Once identified from a photograph these features are unmistakable. The area representing the back of the pelican's head is the brightest part of the nebula. The same instrument requirements for the North America apply to the Pelican Nebula: low magnification, a wide field, and high contrast.

South of the Pelican Nebula lies IC 5068, a detached part of the nebular complex. It is as difficult to detect as the Pelican and appears as a series of wispy patches broken by dark nebulae and roughly aligned east-west.

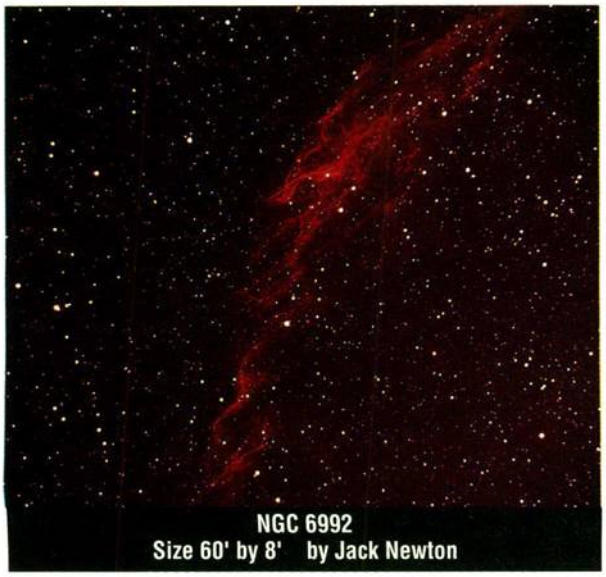
Near the star Gamma (γ) in the center of Cygnus lies another complex bright-and-dark nebula. Designated **IC 1318**, this object consists of a group of large glowing clouds on three sides of Gamma Cygni separated by wide gulfs of obscuring material. The areas south and west of Gamma Cygni are particularly rich in nebulosity. IC 1318, like the Pelican Nebula, is



NGC 6888
Size 20' by 10' by Scott Hicks



NGC 6914
Size 13' by 12' by Martin C. Germano



NGC 6992
Size 60' by 8' by Jack Newton

Nebulosities of Cygnus

Object	R.A. (2000.0) Dec.		Mag.*	Size
NGC 6888	20h12.0m	+38°21'	7.4	20' by 10'
NGC 6960	20h45.7m	+30°43'	—	70' by 6'
NGC 6979	20h48.5m	+31°09'	—	45' by 30'
IC 5067-70	20h50.8m	+44°21'	—	80' by 70'
NGC 6992	20h56.4m	+31°43'	—	60' by 8'
NGC 6995	20h57.1m	+31°13'	—	12'
NGC 7000	20h58.8m	+44°20'	6.0	120' by 100'

Object: Designation in NGC or IC catalog. **R.A. and Dec.:** Right ascension and declination in equinox 2000.0. **Mag.*:** V magnitude of illuminating star. **Size:** Diameter in arcminutes.

much more difficult to see than the North America Nebula. Glancing off to the side of the field and employing your eye's light-sensitive rods, a technique called averted vision, will help you see faint detail in this nebulosity. As with the Pelican, short focal length telescopes in the 3- to 6-inch range work best. Larger scopes go fainter, but at the expense of seeing the complex in its entirety. Be particularly careful when you search for these low surface brightness objects. Several poor star clusters composed of faint stars lie in the area and, at first glance, masquerade as faint nebulosity.

A separate nebula lies about 2° north of Gamma Cygni. This object, **NGC 6914**, has a higher surface brightness and its 6' frame is rather easily visible in small telescopes on dark nights.

Near the southern tip of the IC 1318 complex lies **NGC 6888**, a peculiar filamentary nebula surrounding a Wolf-Rayet star. Whereas the North America and Pelican nebulae are stellar birthplaces in the process of creating clusters of stars, NGC 6888 is a cloud of glowing gas left from the dying puffs of its central star. NGC 6888 lies about a half degree southwest of RS Cygni and is recognizable by the diamond-shaped group of four stars within the nebula. This object is quite faint and measures 20' by 10', giving it a low surface brightness. However, under dark skies it is visible in small telescopes. At the Texas Star Party I have seen it with 7x50 binoculars. In small telescopes only the brightest parts of NGC 6888 are visible. In scopes larger than 12 inches, this object appears as an egg-shaped glow that is nearly a complete shell.

Similar to NGC 6888, Cygnus' grand **Veil Nebula** is one of the sky's greatest sights. Composed of several large strings of glowing light with the designations NGC 6960, NGC 6979, NGC 6992, and NGC 6995, this object is an ancient supernova remnant, the far-flung material from a star that exploded 50,000 years ago. The Veil Nebula covers an area nearly 3° across. Five Full Moons would fit comfortably within its diameter.

The Veil consists of three main elements: the brightest, eastern half, NGC 6992-5; the western half, NGC 6960; and the central section, NGC 6979. NGC 6992-5 is a thin, stringy glow oriented north-south that shows remarkable filamentary structure at high powers. NGC 6960 is a similar north-south nebula that passes behind the bright star 52 Cygni. NGC 6979 is a

The Veil Nebula
by Ronald E. Royer

much fainter triangular nebulosity located in the northern central part of the object.

The best view of the entire object can be had with large binoculars on a very dark night. The two main components of the Veil appear as ghostly streaks set against an incredibly rich star field. To see details in the Veil, however, you must use a telescope. Small scopes show the object faintly but without much detail. Large telescopes, those 16 inches and up, show intricate details in the Veil. Under transparent skies, wispy, lacework structure is plainly visible in both main sections and is unforgettable in NGC 6992-5.

The famous and legendary emission nebulae in Cygnus will provide you with some of your most memorable deep-sky sights and some of your most extreme challenges. Study the positions of these objects carefully on star atlases and photographs, choose the right equipment and a steady, dark night. Above all, have patience. Before you know it, you'll be an old hand at exploring the Veil and charting the faintly recognizable coastline of a ghostly North America floating high overhead. □

Alan Goldstein is the national coordinator of the National Deep Sky Observers Society, a group of active skywatchers founded in 1976. His most recent article was "Great Summer Planetaries," May 1990.

Beneath the Neon Lights

Living in or near a city doesn't mean you can't appreciate the night sky.

by Peter L. Manly

Wouldn't you rather spend more of your observing time looking through an eyepiece than traveling to a dark-sky location? Believe it or not, there is a way to spend more hours at the eyepiece than on the road without sacrificing the joys of observing. The secret is simple: Observe from your home, in spite of the umbrella of light cast into the sky by the city.

Although city lights certainly don't help if you have a penchant for observing deep-sky objects, they don't interfere with solar, lunar, planetary, double star, variable star, and open cluster observing. Moreover, your backyard is more accessible than a dark-sky site fifty or one hundred miles away. At home, you can walk outside, observe for fifteen minutes or an hour, and then go back inside. In 1987, for example, I observed on 111 nights of the year from my backyard. Some of my observing sessions lasted only a few minutes.

If you're so inclined, you can also conduct serious observations from your bright-sky site. Amateur/professional organizations such as the Association of Lunar and Planetary Observers (ALPO), the American Association of Variable Star Observers (AAVSO), and the International Occultation Timing Association (IOTA) were formed to gather and archive amateur observations and supply needed data to professional astronomers. Although practically any backyard site will do, observing with the intent of gathering useful scientific data requires a long-term commitment and a willingness to gather oftentimes repetitive data. A backyard site is convenient and eases the burden.

Astronomy at home can also transform your hobby into a meaningful family activity. You can get your spouse and children to look through a telescope if all they have to do is step outside. Of course, I don't know if my kids' enthusiasm is based on an abiding interest in astronomy or if they just like staying up late and having daddy's undivided attention every time we drag out the telescope. What matters is that we spend more time together when I observe at home.

To get the most out of city observing, you need only take a few common-sense steps. It may seem obvious, but avoid direct lights. Shield your backyard site from street lights, automobile headlights, and your neighbor's outdoor lighting. You can use your hand or a friendly observing companion as a light shield or go so far as to construct a portable screen from plywood or cloth. Some observers drape black cloths over their heads at the eyepiece. At home I move my telescope around the yard to avoid trees and local lights.

Use moderate- to high-power eyepieces. Low-power eyepieces have wide fields of view and a bright sky background, thus yielding low-contrast images. This is especially true for star clusters and bright nebulae or galaxies. The smaller field of view in a higher power eyepiece artificially darkens the sky background, allowing your target to stand out a bit more in contrast.

What can you see? Well, you actually *can* see some deep-sky objects. The Orion Nebula and the Andromeda Galaxy come immediately to mind, not to mention bright open clusters like the Pleiades and the Double Cluster. Depending on your scope's aperture and how bright your sky is, nearly all of the Messier objects can be seen from the city. The recent supernova in M66 was observed and measured on several nights from a rooftop observatory in North Phoenix, and yes, the galaxy's nebulous disk was seen in addition to the supernova itself.

Rediscover the Moon

Many deep-sky observers hibernate during the brighter phases of the Moon, but they're missing a

spectacular astronomical object. Observing the varying aspects of lunar features, such as the shadows crossing craters or the fine details of rilles and craterlets, can be a very rewarding pursuit. You can observe visually or sketch what you see.

Lunar observations are generally not hampered by city lights. This is because the moonlight itself is usually much brighter than any reflected light from terrestrial sources. Consequently, the amount of lunar detail visible from the country and the city is essentially the same.

The lunar day is one Earth-month long. At any location on the Moon, the Sun rises once every twenty-nine and a half days and sets fourteen days later. During this extended day the shadows of lunar features change and reveal the shape of the landscape. By comparing the lengths of shadows cast by hills and crater rims, a picture of the roughness of the terrain can be pieced together.

For the inquisitive lunar observer, there is the study of Lunar Transient Phenomena (LTP), which includes, but is not limited to, monitoring specific craters for changes in brightness, color, or surface features. While the nature of LTPs is a controversial subject, the observing program itself is a valid scientific study that only requires a small telescope, a keen eye, and patience.

ALPO is currently interested in amateur observations of lunar domes (low hills), transient lunar phenomena, selected surface features, and lunar eclipses.

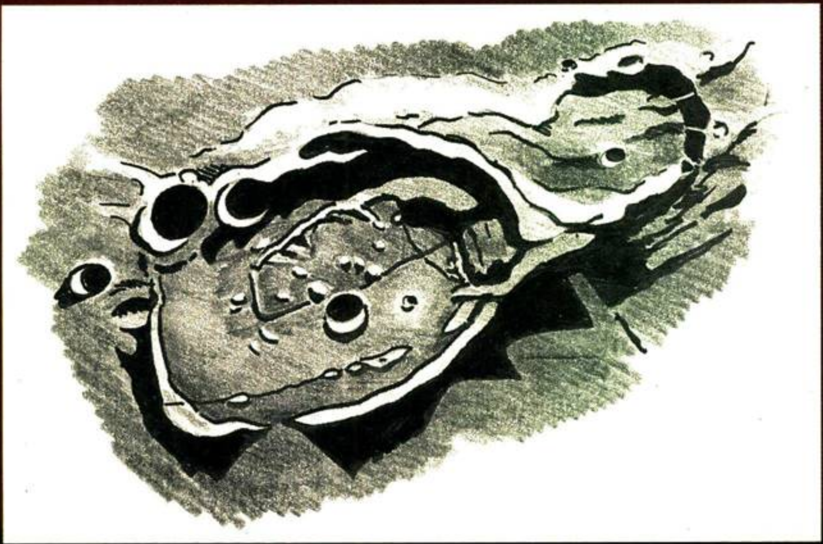
Survey the Solar System

Like the Moon, the planets are as accessible from the city as they are from the country. One of the intriguing aspects of planetary observing is witnessing the changing surface and atmospheric features on Mars, Jupiter, and Saturn. You can look at Jupiter, for example, again and again without seeing the same details twice. The planet's satellites will be in a different location or the cloud features will appear darker or shaped differently.

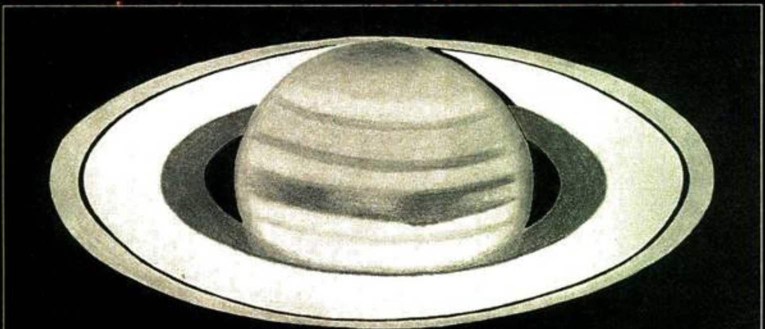
Many beginning observers report that planetary disk details are difficult to distinguish, which is true for the untrained eye. One of the best ways to coach the eye to see subtle features is to sketch what you see or describe your views in an observing log. As the eye and brain work together you flex your perception skills more and more and subtle features begin to emerge that previously went unnoticed. You'll soon find that there are subtle changes almost every night.

The polar caps and dark surface markings of Mars are fairly easy to detect using a small scope at moderate to high magnification. More elusive features, however, must await favorable periods when the Red Planet is both nearest Earth and the Sun, which this year occurs in late November. Mars exhibits a large disk and the planet's weather is dominated by the Sun's heat. Surface and atmospheric features are easy to see in a 6-inch scope, and they change from night to night. Over several months you can watch the polar caps shrink or grow, depending on the planet's season and distance from the Sun, while other features change in color and shad-

A 24-HOUR-OLD MOON sets over El Cajon. California. The night sky holds many opportunities for urban observers. Photo by Jerry Schad.



THE MOON LOOKS JUST AS GOOD from the city as from the country. And there is a world of features to explore, like the craters Posidonius and Chacornac, sketched here by Marc Daniels.



FORGET ABOUT THE SHOPPING MALL down the street. All you need to see Saturn's rings and disk features are a telescope and a clear sky. Sketch by Michael E. Sweetman using a #12 yellow filter.

ing. Continuous monitoring of these areas is an enjoyable pursuit. Some surface and atmospheric features can be enhanced with inexpensive colored filters (available from telescope dealers) that screw onto your eyepiece.

Jupiter's disk also presents many interesting telescopic features. Belts and spots appear and disappear, colors change, and there are occasional outbursts of atmospheric activity. Jupiter rotates so rapidly (in about 10 hours) that a new cloudscape appears every couple of hours. The atmospheric features, too, respond well to colored filters.

One of the most famous Jovian features is the Great Red Spot, located in the South Equatorial Belt. This long-lived cyclone has always attracted the observer's eye. For the past decade the Great Red Spot has been a blanched pink spot, and consequently not as prominent. Recent observations, however, indicate that this feature is growing redder and should appear more prominent in small telescopes.

Your observations of the Red Spot also have the potential for contributing to science. Timing the central meridian transit of this feature and recording its color and shape are important to understanding the overall weather patterns on Jupiter.

Saturn's bands and spots are more challenging to observe than Jupiter's because they have less contrast. Careful scrutiny of the disk may reveal white spots or bars of dark material punctuating the bland atmosphere. The north polar region, which is currently tipped more than 20° in our direction, also varies in duskiness. The rings, of course, are always a fascinating study. The challenge is to look for the narrow, dark ring gap known as the Cassini division or the angular shadow of the ball cast across the rings "behind" the planet.

An elusive faint glow on Venus has often been reported on the planet's night side during its crescent phase, most often during evening apparitions. This elusive phenomenon is called the ashen light. Once thought to be a perception effect, scientists speculate that the ashen light may have a physical cause, such as aurorae or lightning in the upper atmosphere.

ALPO has been collecting drawings of the ashen light for years. In addition, cloud features on the sunlit side of Venus have been reported and sketched. Often these shadings are best seen with blue or violet filters.

Urban Planetary Science

A lot of routine planetary observations these days are being done by amateurs using small scopes and living in or near cities. This is because professional observatories simply do not have the telescope time or staff to regularly monitor the planets for changes. The majority of amateur data consist of visual observations and sketches. A carefully drawn sketch usually shows more detail than conventional photographs.

While many of these observing projects require maintaining a routine observing schedule, there are phenomena that you can plan in advance to observe. Jupiter's satellites, for example, disappear into the great planet's shadow and reemerge at predictable intervals. From time to time the satellites transit, or pass in front of, Jupiter and cast a shadow on to the planet. Careful timings of transits and occultations refine our knowledge of the orbits of Jupiter's satellites. (Approximate times for these events are frequently listed in the Sky Almanac section of this magazine.)

A KIND OF VISUAL POETRY is intrinsic to occultations and close conjunctions of the Moon and stars. Here the Moon and Aldebaran form a graceful pair in the evening sky. Photo by Glenn Lambert.

Another type of bright-light astronomy is observing lunar occultations. The Moon often passes in front of stars and sometimes star clusters. Watching a star wink out behind the lunar limb or suddenly reappear from behind the Moon is easy to do with a small scope.

Occultations also provide the opportunity to do a little science. Determining the exact time of the star's disappearance and reappearance can help refine the position of the Moon and aid in mapping the lunar limb. One of the purposes of the International Occultation Timing Association is to help astronomers by calculating the approximate times of occultation events.

IOTA also coordinates observations of asteroids passing in front of stars. Asteroids are usually too faint to detect, but the stars they occult are often easily visible in small telescopes. By timing how long and how much a star's brightness is dimmed, the size of the asteroid can be determined. Typically one or two occultations of stars by asteroids may be observable each year from a given region of the country. Notices of occultations are published in the Sky Almanac and a number of annual observing guides, such as *The Observer's Handbook.*

Double and Variable Stars

Of course there's more out there than just the solar system. Bright double and variable stars are easy to observe from the city. In fact, double stars usually show up as well in light-polluted skies as they do in dark skies. This is because double-star observing requires moderate- to high-power eyepieces, and stars are bright point sources.

There are thousands of double and even multiple stars within reach of small- to moderate-size scopes. Their sometimes narrow separations and great brightness differences will test your observing skills and your telescope.

Variable star observing is another bright-light pursuit that is fun as well as valuable to professional astronomers. There simply aren't enough people or telescopes to monitor the hundreds of thousands of variable stars. The American Association of Variable Star Observers supplies finder charts for stars of interest and instructs newcomers on how to gather meaningful magnitude data. Typically, estimating a variable star's magnitude involves comparing its brightness with one or more stars with well-established magnitudes that lie in or near the same field of view.

Bright-light astronomy can be a rewarding pastime that you can become as deeply involved in as you like, from a few casual minutes in the backyard now and then to the major commitment of a long-term observing program coordinated by national organizations. □

Peter L. Manly is an amateur astronomer and an aerospace engineer living in Tempe, Arizona. A nearby football stadium, which illuminates his backyard, served as the inspiration for this article.

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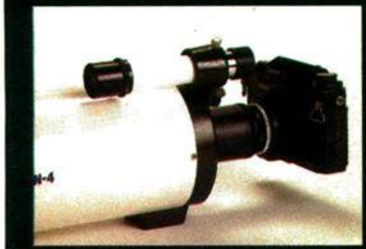

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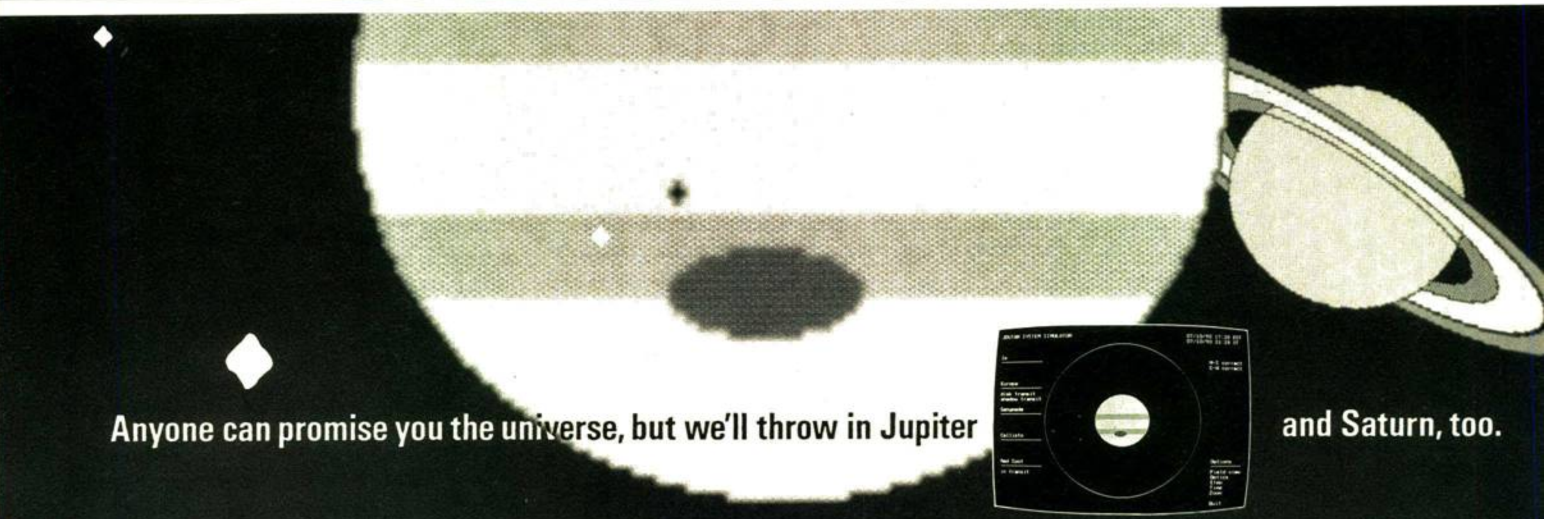
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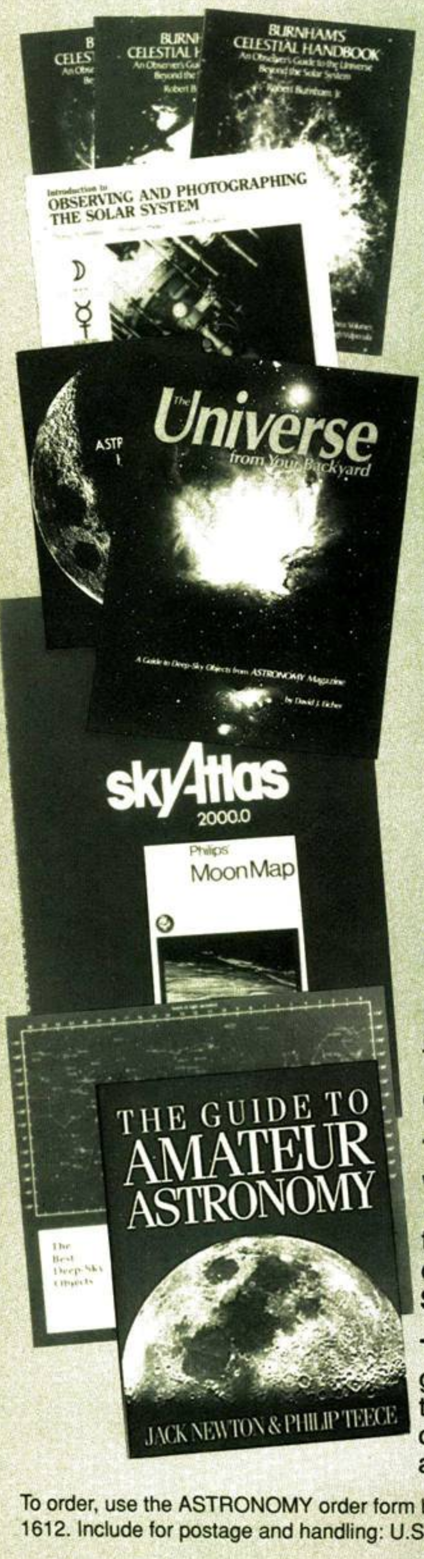
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THE LURE OF THE HORSEHEAD

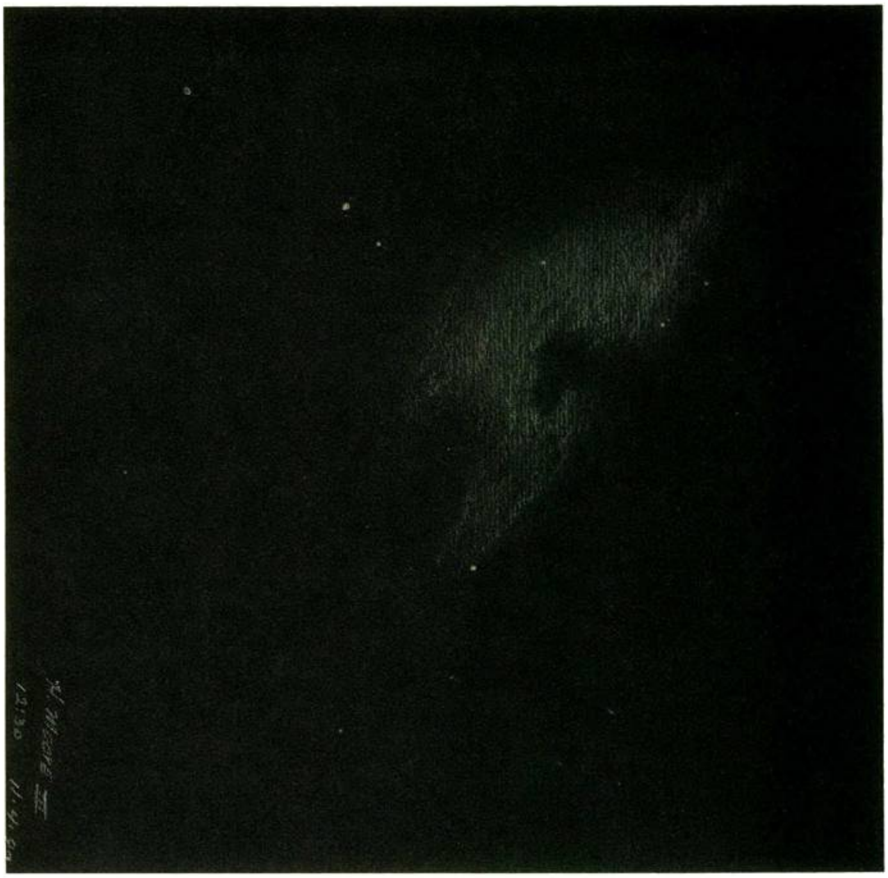
The Horsehead Nebula in Orion is one of the most renowned targets for backyard observers. A small cloud of dark dust suspended in front of a streak of dimly glowing emission nebulosity, the Horsehead is out of the reach of small telescopes and is visible in large scopes only under the best conditions. The primary factors for success with the Horsehead are knowing exactly where to look, what to hunt for, and viewing only on a night of exceptional clarity.

"I began my search for the Horsehead Nebula in January," said M. Leon Knott of Rock Hill, South Carolina. "I used a 13.1-inch f/4.5 reflector, a 20mm eyepiece that yielded a magnification of 73x, and a UHC filter. The most helpful tool was *Uranometria 2000.0,* which was invaluable for zeroing in on the Horsehead. It was tremendously reassuring to know I was aiming the telescope at exactly the right spot."

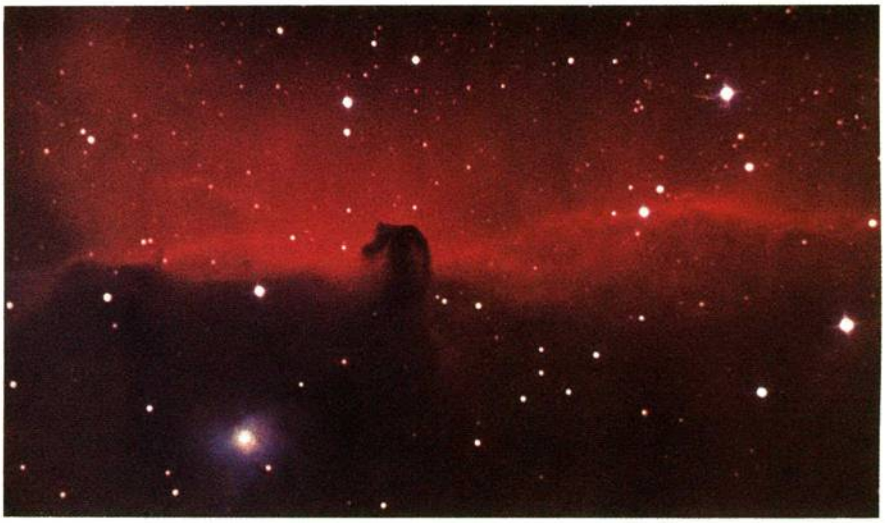
Just as important as the equipment is the observing site. "Our site in northern South Carolina is only moderately dark," said Knott. "So I wanted to attempt to see the Horsehead only when it was near the meridian. After placing Zeta Orionis at the very edge of the field, I covered my head with a black cloth and began to look carefully. After several seconds I could see a line running through the field that seemed to separate an inky black side from a slightly lighter side. I realized that this lighter nebulosity was IC 434, and that the Horsehead Nebula should be visible against part of this exceedingly faint glow.

"For a short time I stared and tried to perceive the Nebula," Knott continued. "Then I simply relaxed my eye and it finally came into view. I saw the Horsehead as a rather large indentation in the bright nebula. The Horsehead was shaped something like a bloated question mark. As I continued to examine the field, the Horsehead became slightly easier to see and its edges appeared sharper than when I first saw it.

"The greatest joy came in sharing the observation with a friend," said Knott. "A few weeks after my first sighting I was able to show the object to Howard Moore III, an excellent artist who produces fine eyepiece drawings of deep-sky objects. Howard used my newly completed 20-inch reflector to produce a drawing that shows how subtle the Horsehead Nebula appears even in large backyard telescopes."



THE HORSEHEAD NEBULA is barely visible against the faint glow of IC 434 in Howard Moore III's sketch made with a 20-inch f/4 reflector.



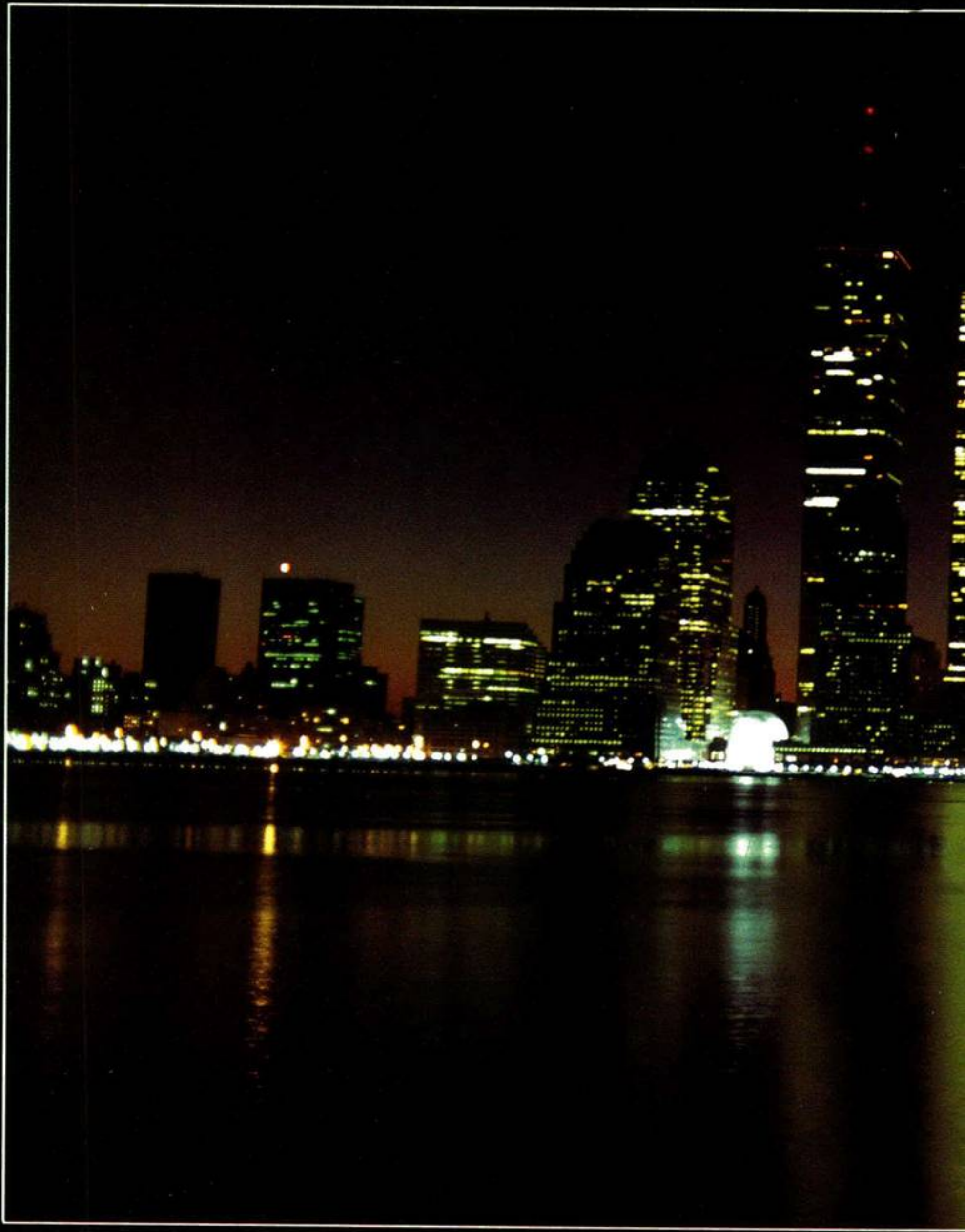
THE UNIQUE SHAPE of the Horsehead Nebula shows up easily in photographs of the region. Photo by Jack B. Marling.

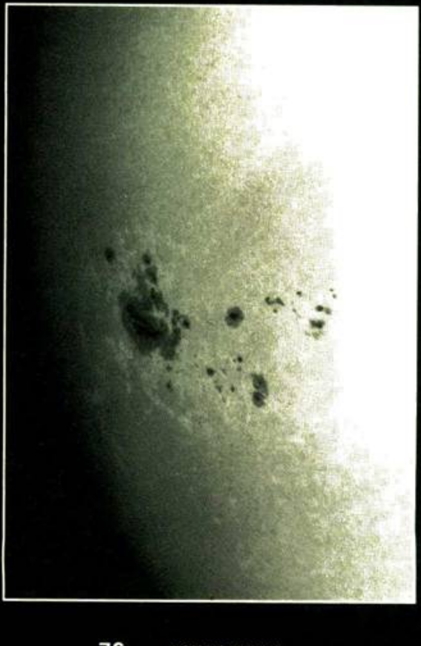
THE BEAUTY OF CITY OBSERVING

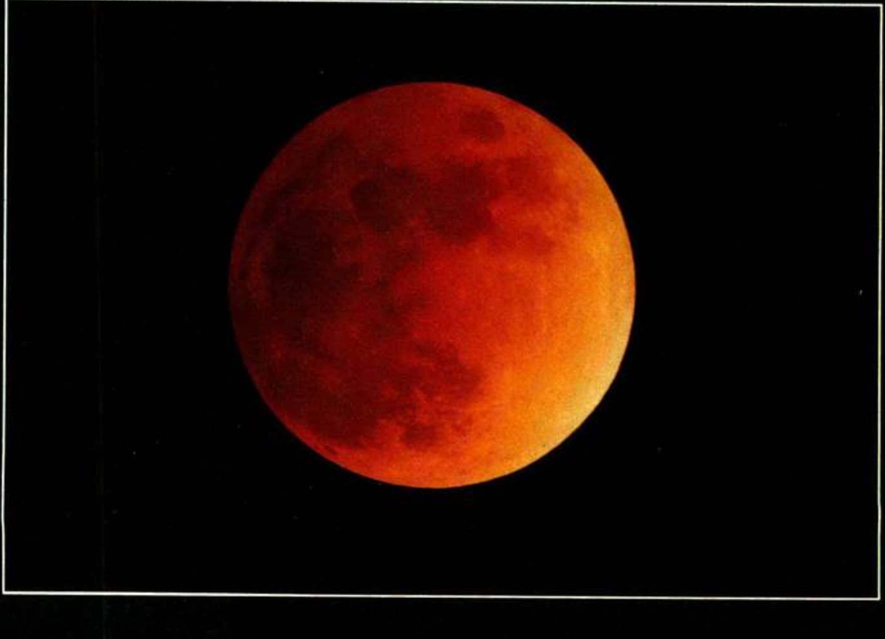
Astronomy from the city is far from impossible, as Peter Manly describes in "Beyond the Neon Lights" (page 70). Larry Landolfi's photograph of Venus, Saturn, Mars, and the Moon over Manhattan illustrates the beauty of observing bright celestial objects under urban skies. Landolfi used a 28mm f/4 lens, Kodachrome 64 film, and a 10-second exposure for the photo, which wins this month's $100 "Best Astrophoto" award.

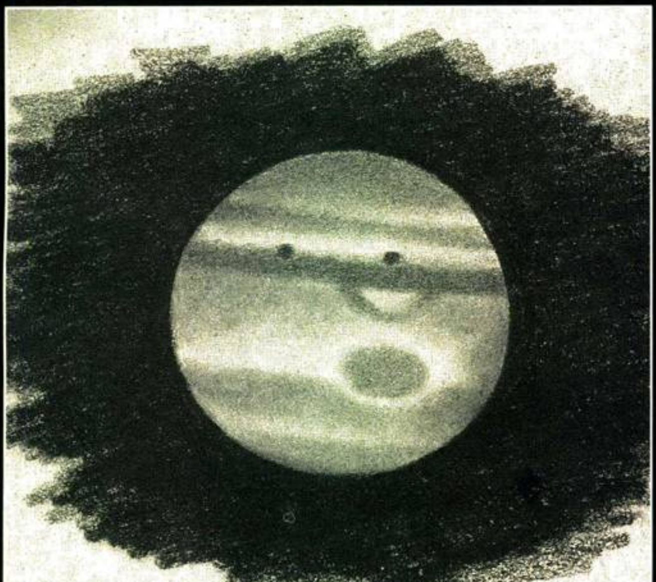
H. C. Ng achieved a much different view of the Moon during this winter's total lunar eclipse visible from Earth's eastern hemisphere on February 9 (below, right). Gordon Garcia's white light photo of a large sunspot group (below) was made on June 18, 1989. Garcia used an 8-inch SCT at f/84, Tech Pan film, and a 1/500-second exposure.

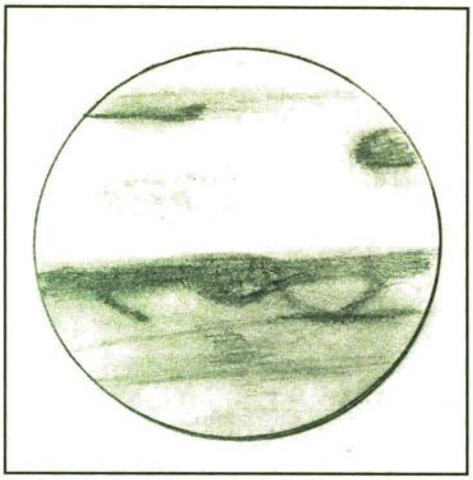
The giant planet Jupiter's unusual appearance has fascinated observers for several months. Terry Smith's sketch of the planet (bottom center), made with a 4-inch refractor on January 7, approximates the small telescope view during the first few weeks of the 1990s. On February 10 Gregory Terrance photographed the planet and recorded the darkening Great Red Spot and the absence of the South Equatorial Belt (bottom right).



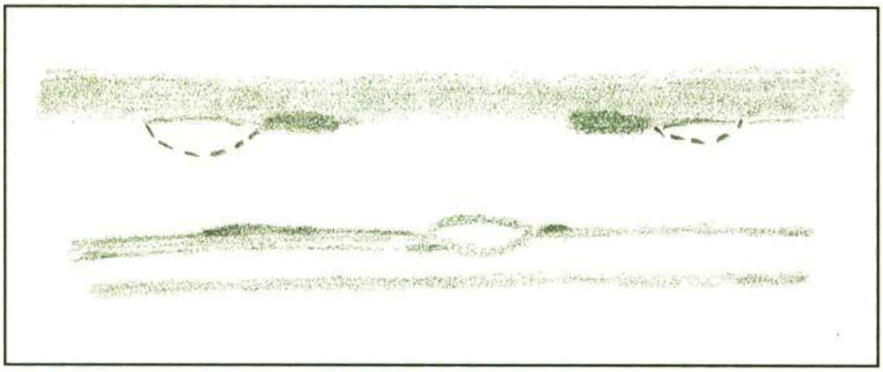








AN ODD-LOOKING JOVIAN DISK was visible through the first few weeks of 1990. Chrisantha Fernando's sketch of Jupiter on January 23 shows the Great Red Spot on the planet's limb.



RARE WHITE SPOTS were visible in Jupiter's North Temperate Belt on February 25. Philip W. Budine sketched the event with a 4-inch refractor at 167x and 214x.

THE UNUSUAL SHOW ON JUPITER

Jupiter's strange behavior continued during the first weeks of 1990. Ever since the planet's South Equatorial Belt faded to invisibility last summer, observers have enjoyed a spectacular display of atmospheric phenomena. Over the past few years the planet's famous Great Red Spot has also paled. Recently, however, the spot has intensified in color. And during the last few days of February white spots were visible in the planet's North Temperate Belt.

Observing with a 6-inch reflector from Bristol, England, Chrisantha Fernando has monitored Jupiter for the past six months. "There is a great deal going on apart from the SEB disappearance," said Fernando. "The North Equatorial Belt is prominent with lots of condensations and extensions, wisps, and festoons. The South Temperate Belt, though broken, is prominent in several areas. The North Tropical Zone is bright in some parts and dark in others. The planet's South Polar Region seems to be getting lighter." — *David J. Eicher* ☐

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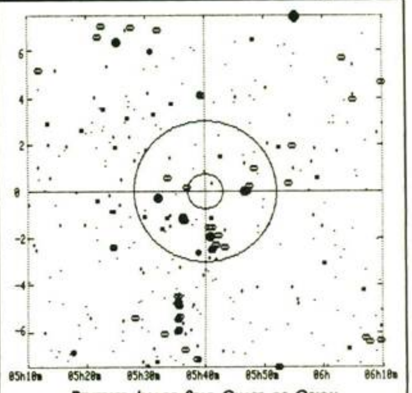

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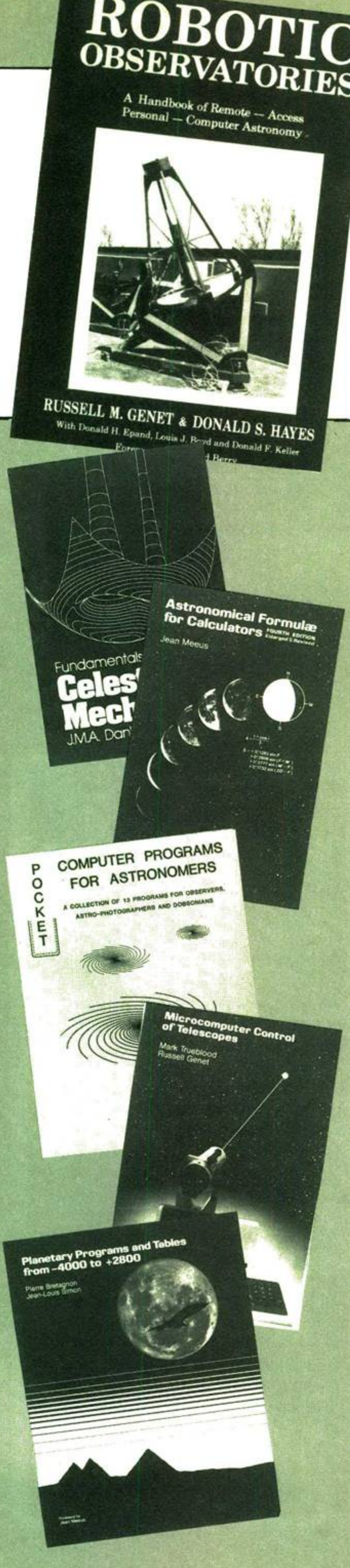
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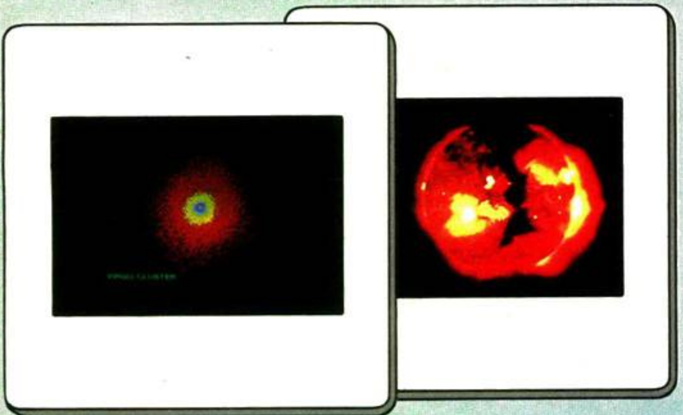

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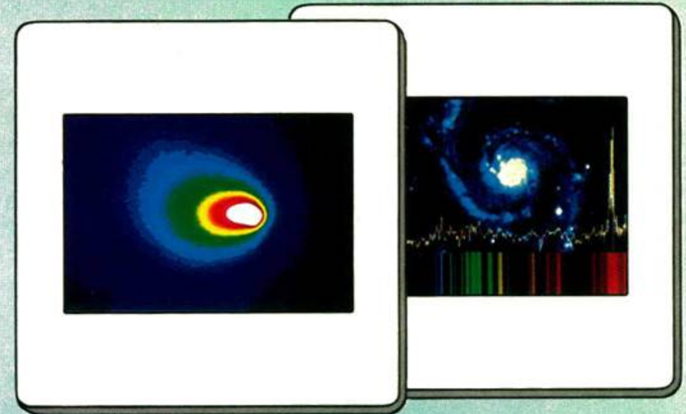

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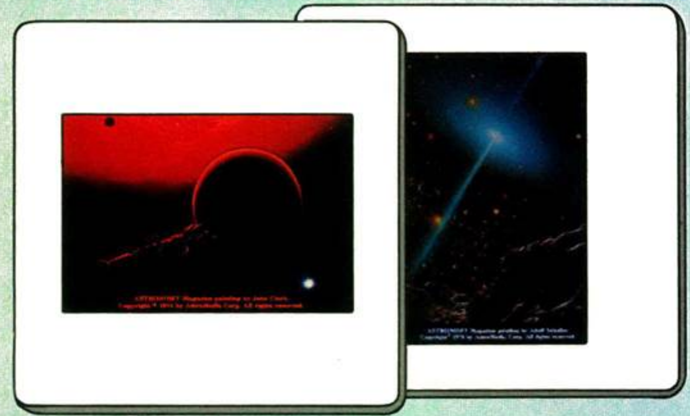

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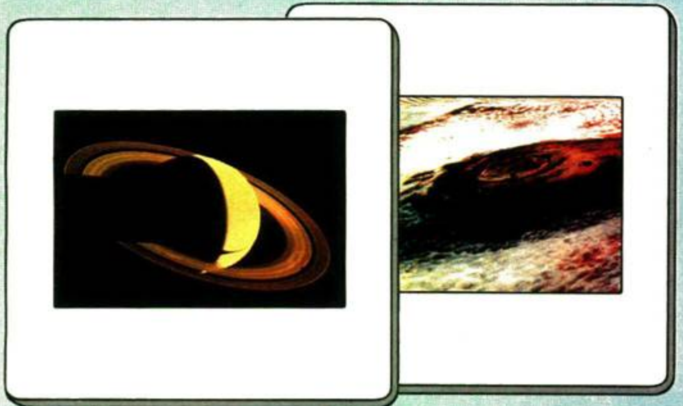

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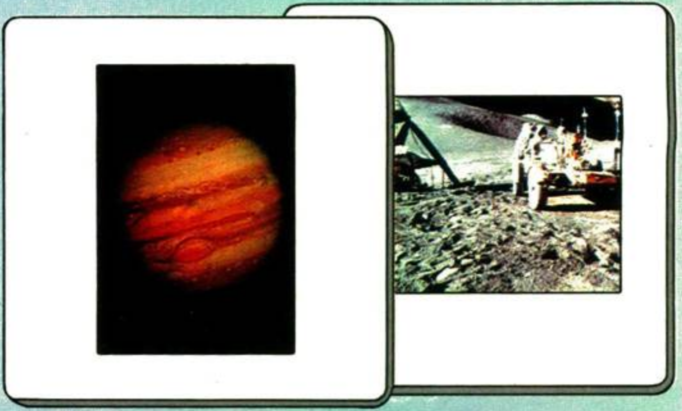

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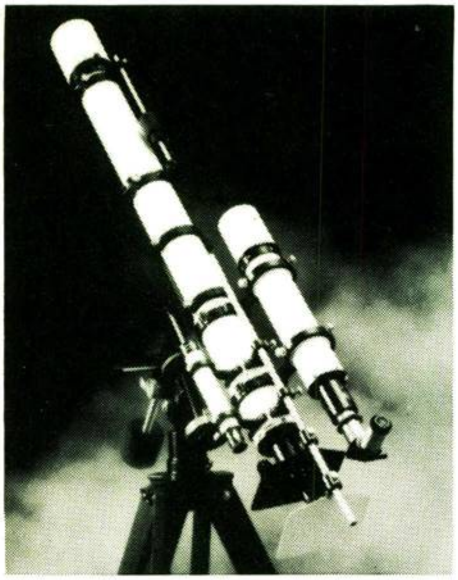

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IN THE FOREST GALACTICA

We use the West Sturgeon Forest Road as a shortcut between our cabin and Beatrice Lake. The narrow track winds through hills full-flocked with pine and birch. The road branches off the pavement and heads northwest. Norway pines shadow a sandy grade littered with needles and cones.

The look is deceptively sylvan, as if this is just another woodland route for loggers and hunters. Yet this bumpy and sometimes rutted road leads to the center of the Galaxy.

Beyond the crest of the first rise the road makes a long, rolling drop to the edge of a beaver pond and then cuts due north. We usually travel the road at night, so the pond is lost in blackness. On warm summer evenings we catch whiffs of muskeg and peeled aspen — earthy, primeval odors that are pure biology. The scene is richly terrestrial, but as we climb the next hill we're approaching escape velocity.

The car is aimed at the sky and we're driving for the Big Dipper, or so it's easy to imagine. The hill is a local high point, logged off and replanted five years ago. The young pines haven't yet grown tall enough to veil the horizon and crowd out Polaris. For at least a few more years the hill will remain a natural observatory, the kind of place where a shaman could rearrange stones to survey the solstices and the symmetry of the Great Spirit's fires.

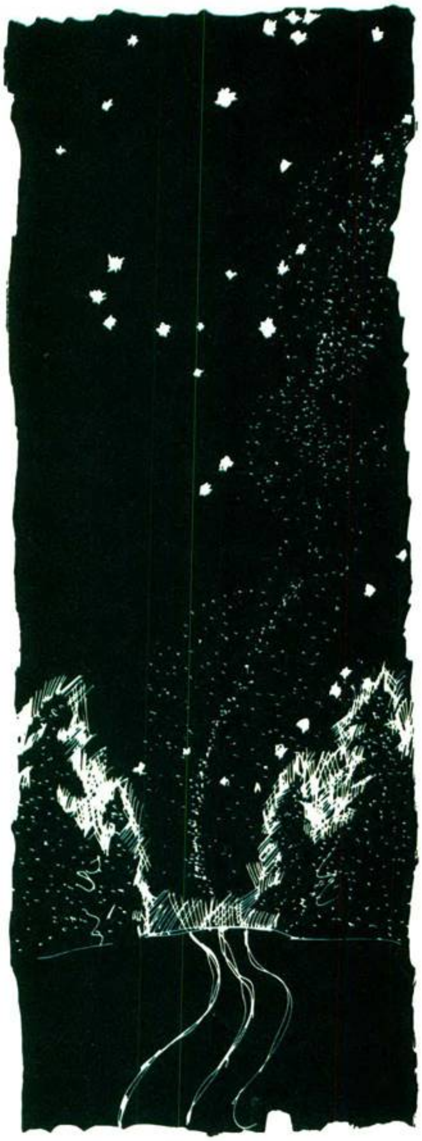
The headlights of the car seem a sacrilege and an intrusive reminder of the modern magic that seeks to banish night from the planet. I switch them off at the top of the hill and we roll to a quiet stop.

It's here, as the wheels halt and the engine dies, that we pick up speed. Silence is the key. It lets us now soar, freed from our machine, exposed to the soft emanations of the Milky Way. If the timing of our ascent has been lucky, we can watch the northern lights rage across the stars in waves of banshee light.

More than a dozen miles from the nearest street lights, the sky is dark here, uncontaminated by channeled electricity. It's a natural blind for comet hunters, and it lies in the path of a cosmic axis that stretches from infinity to a focus at the lens of one's imagination.

In the hollow of a summer dusk the constellation Leo is "setting" in the west. It's a pleasant illusion. In reality the planet and our eyes are spinning from west to east at nearly a thousand miles an hour. The bright star Regulus, the heart of the Lion, isn't really sinking behind the tree line. Rather, the trees reach to swallow it as the limb of the Earth rises up and around. If you stare at the stars and watch the trees you can sense the slow, heavy tread of the celestial gyros.

But this is only one part of the cosmic maelstrom. I recall how the hill slept in winter, a white, drifted desert under the orange gleam of Aldebaran, and I know the seasons are also the



product of motion. Our forest road and all the rest race around the Sun at 66,000 miles per hour — 18 miles per second — from January into July.

If I turn from Leo to face eastward and then look almost straight up, I'm focused on the figure of Hercules. Our Sun and its planets are speeding through interstellar space toward a point in Hercules at 43,000 miles per hour. The solar family is also enmeshed in one of the spiral arms of the Galaxy, revolving around the core of the Milky Way at 630,000 miles per hour. Velocities within velocities, orbits within orbits. And where is the Galaxy going? Out, way out, toward a place with no name.

From the top of this woodland hill my view of the universe is as wide as anyone's. I'm a *de facto* cosmologist, my own high priest and solemn intermediary between the source of the galaxies and the part of me that's not part of my body — the potent but ephemeral mixture of perception and understanding. The human mind is an epiphenomenon. It's greater than the sum of its physical parts. You cannot touch the mind or even point to it, but at night on the West Sturgeon Forest Road you feel it expand.

One midnight in early June we paused on the hill and got out of the car. The Milky Way was a snowy belt of suns connecting the horizons. The constellations blazed at full power, the major patterns half-hidden by stars never seen from the heart of civilization. It was a perfect night for interstellar travel.

But look at the woods! The meadow of young pines was full of lights. They danced and flickered among the trees, blinking on and off like twinkling stars come to Earth. Fireflies. Except for the black silhouettes of the forest, there was no difference between Earth and sky. I tried to count the moving sparks and quit at a hundred — you might as well count the stars.

I looked up at Vega, firefly-colored and 22 light-years away, and looked back at the shining zodiac of fireflies. The scale was impossible. How far is a firefly? Fifteen feet or a quantum leap? The illusion of stars in the woods and insects in outer space was nearly perfect, like setting Leo. Is there so little difference between stars and fireflies, between a road and the Milky Way?

Perhaps it comes down to the road. Cruising toward Beatrice Lake and crunching pine cones beneath the tires, we are also cruising the Galaxy. And so are the fireflies. — *Peter Leschak* ☐

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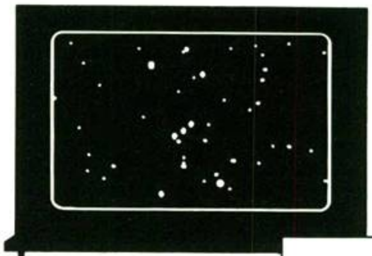

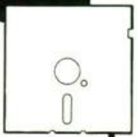

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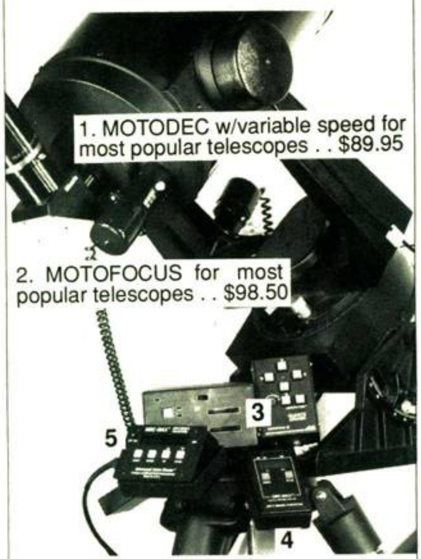
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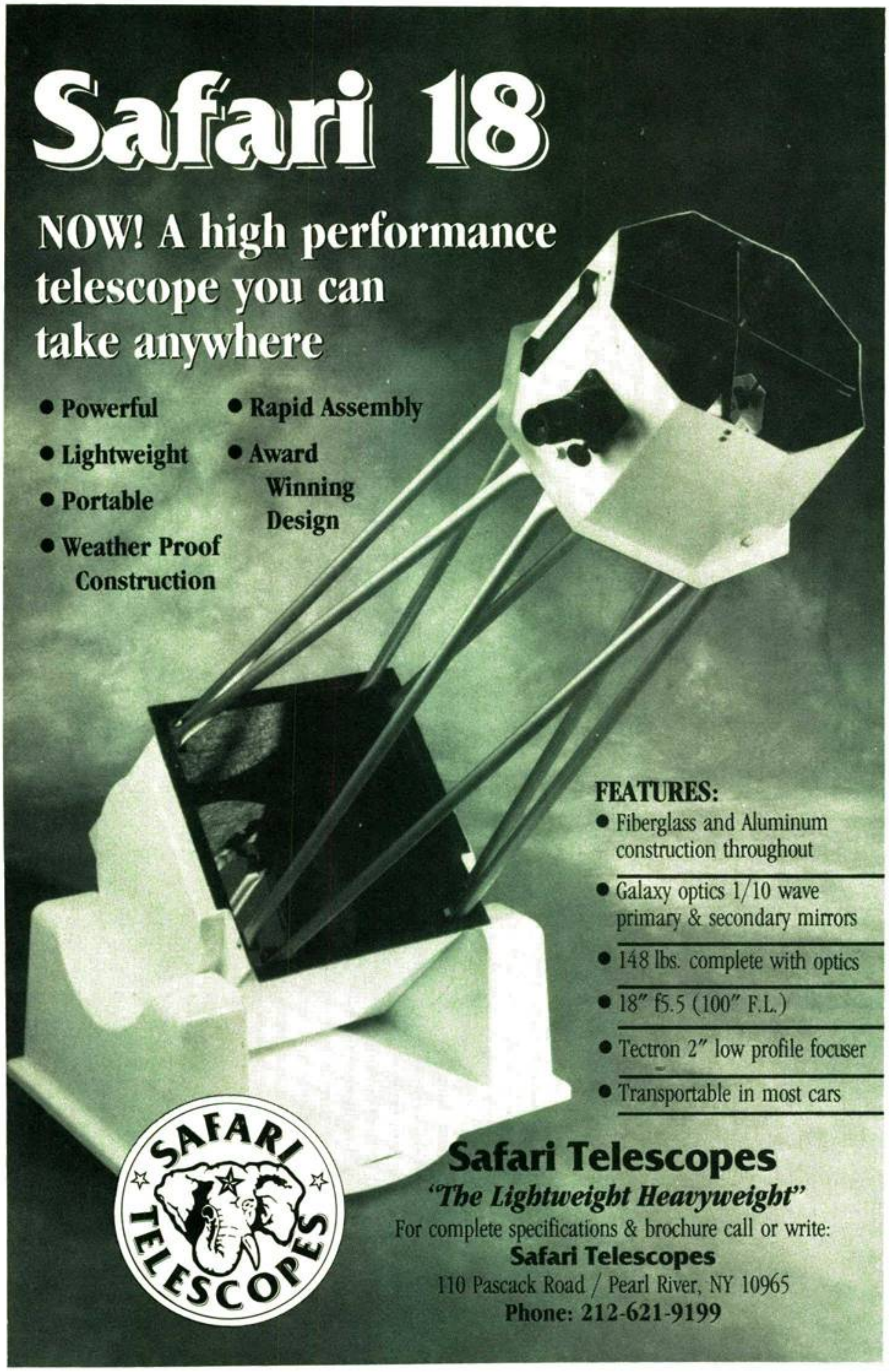

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NOTICE — The South Jersey Astronomy Club meets the 1st Thursday of each month at Vineland City Hall at 7:30 PM. The club is open to all and is an I.D.A. member. For more info, visit out next meeting or contact Fred Schaaf, R.D. #2, Box 248, Millville, NJ 08332.

WANTED — World-wide correspondence with people interested in astronomy and astrophotography. Will reply to all letters. Contact Dwayne Medel, 3653 E. Townline Road, Birch Run, MI 48415, USA.

WANTED — Fifteen-year-old teen seeks correspondence with other teens interested in astronomy. Will respond to all letters. contact Brandon Eggett, 23 S. Highland Circle, Elk Ridge, UT 84651.

WANTED — 4" refractor, f/5 to f/9, Genesis, Renaissance, Brandon 94mm, Celestron Flourite or other highest quality optical tube assembly. Also, 2" eyepiece 32 to 40mm, and 30 to 35 mm, 1 1/4". Contact Dea Warford, 21212 Norwalk, Hawaiian Gardens, CA 90716. Phone: (213) 860-3024 or (714) 687-4460.

ANNOUNCEMENT — Concordia Astronomy Club, current membership 120. Contact Eli Drapkin or Arnold Epstein, P.O. Box 22, Jamesburg, NJ 08831-0022. Phone: (609) 655-1422 or (609) 395-0755.

ANNOUNCEMENT — The Martz Observatory will hold its second annual Astronomy Weekend '90 on April 27-29, 1990. The weekend will include workshops, slide and video presentations, and most importantly *observing*. The newly refurbished 30" f/4 German Equatorial Newtonian will be highlighted, among others. Guests are invited to bring their own telescopes. Camping and accommodations are available within a few minutes of the observatory (located 12 miles SE of Jamestown, NY). Our southern horizon overlooks the Allegheny National Forest and has a magnitude 6.5 naked-eye limit. Contact Liz Kales at (814) 757-9266.

ANNOUNCEMENT — The Small Scope Observers Association (SSOA) is seeking members. Old members of the SSOA are invited to contact us about our renewed activities, ans as always, new members are welcome. Send SASE to SSOA, 4 Kingfisher Place, Audubon Park, NJ 08106.

ANNOUNCEMENT — The Bucks-Mont Astronomical Association meets the first Wednesday of each month in the farm house at Tamanend Park, located on Route 232 just north of Street Road, Southhampton, PA. Contact Alan Pasicznyk. Phone: (215) 348-2385.

A HANDY GUIDE TO THE CONSTELLATIONS

Observing the Constellations by John Sanford, (Simon and Schuster, 1989), ISBN 0-671-68924-X, softcover, 176 pages, $16.95.

For fifteen years the three volumes of *Burnham's Celestial Handbook* have been an indispensable part of every amateur astronomer's library. Their rich collection of astronomical facts along with descriptions of hundreds of celestial targets has made *Burnham's* something of a deep-sky encyclopedia. But the problem with Burnham's handbooks is that the sheer amount of information is overwhelming, especially to someone just getting into the hobby.

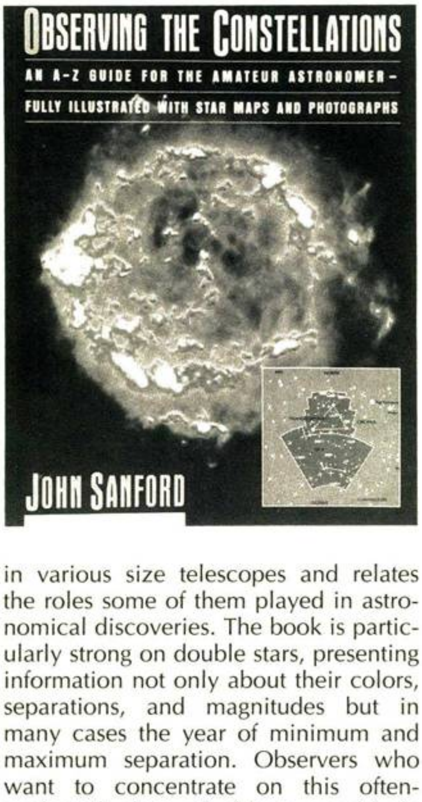
And yet those of us with telescopes and the desire to explore the sky need some expert advice on what to look for among the stars. What's needed is a thorough but not preponderant constellation-by-constellation guide to the sky's wonders. *Observing the Constellations* serves that purpose very well. Written by California amateur astronomer John Sanford, *Observing the Constellations* is a thorough guide to hundreds of nebulae, clusters, galaxies, variable stars, and double stars.

The format Sanford has selected is fairly standard for constellation guidebooks. The constellations are ordered alphabetically, and all eighty-eight are represented. The southern constellations are given equal importance, something readers in the tropics and the Southern Hemisphere will appreciate. Each constellation (or in some cases group of constellations) receives at least a two-page spread, with some of the more interesting constellations warranting four pages. Each spread contains a well-executed star chart, a photo of that region of the sky to match the chart, and a table summarizing the constellation's double stars and deep-sky objects.

The constellation charts are the book's most attractive feature. Drawn by renowned celestial cartographer Wil Tirion, these charts are similar to his *Sky Atlas 2000.0* in style, but they only plot stars down to 6th magnitude and include fewer deep-sky objects. These charts are more complete than similar constellation charts Tirion has drawn for other handbooks. They also work well under red light, a consideration that many guidebooks neglect.

Although the charts are excellent, the same cannot be said of the constellation photos that accompany the charts. It might seem like a good idea to include an actual photo, but these are of little value. Perhaps because of poor reproduction the stars are very faint, with little dynamic range between bright and faint stars. Bright, distinctive constellation patterns like Cassiopeia's W-shape look lost. Even experienced observers may have a tough time picking out the constellation patterns in these photos. Slight differences in scale, orientation, and framing between the photos and the charts make the comparison even more difficult.

The text deals with interesting celestial objects in each constellation. Sanford describes how these objects appear in various size telescopes and relates the roles some of them played in astronomical discoveries. The book is particularly strong on double stars, presenting information not only about their colors, separations, and magnitudes but in many cases the year of minimum and maximum separation. Observers who want to concentrate on this often-neglected class of objects would do well to buy this book just for its double-star information.


OBSERVING THE CONSTELLATIONS
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The selection of objects Sanford has made, as well as his descriptions, are excellent. The book clearly benefits from Sanford's years of experience at the eyepiece. Unlike older guidebooks, and even some newer ones, the content of the book reflects current observing techniques, such as the use of nebula filters and large-aperture telescopes.

But no book is perfect. While it is profusely illustrated, I felt that many of the photographs are thematically out of place in an amateur guidebook. Fewer false-color contour maps, infrared and x-ray images, and other professional photos and more amateur astrophotography would serve the book's purpose and audience better.

The four-page introduction is too short. A lengthier opening chapter providing the novice reader with enough background to understand the text would have been more useful. For example, the book does not explain angular size or the Hubble galaxy classification scheme, yet these terms are freely used in the object descriptions.

Despite these shortcomings, *Observing the Constellations* is a readable and up-to-date survey of deep-sky wonders. Anyone setting out to explore the sky with a telescope will find Sanford's book well worth owning. — *Alan Dyer*

BOOKS RECEIVED

Astrophysics

Physics of Black Holes by Igor D. Novikov and Valery P. Frolov, (Kluwer, 1989), ISBN 90-277-2685-X, hardcover, 341 pages, $99.00.

This book focuses on presenting mathematically the properties and theories of physical effects in the vicinity of black holes. Topics include spacetime distortions, rotating black holes, electrodynamics, quantum effects, and the thermodynamics of black holes, internal structure, and primordial black holes.

Cosmology

The Universe in Time by Paolo Maffei, (MIT Press, 1990), ISBN 0-262-13236-2, hardcover, 407 pages, $29.95.

The third volume in a loose trilogy by Italian astronomer Paolo Maffei that began with *Beyond the Moon* and *Monsters in the Sky*, both published by MIT Press. Maffei takes the reader on a tour through time from the birth of the universe and the planets to the origin of life on Earth. The book covers a wide range of topics including galaxies, star formation, the possibility of natural catastrophes on Earth and in the solar system, the greenhouse effect, and the threat of humankind's self-destruction through nuclear war. The content is technical, however, and may discourage readers with modest science backgrounds.

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Galaxies

Active Galactic Nuclei, edited by Donald E. Osterbrock and Joseph F. Miller, (Kluwer, 1989), ISBN 0-7923-0256-7, hardcover, 592 pages, $129.00.

Active Galactic Nuclei comprises the proceedings of the 134th Symposium of the International Astronomical Union held in Santa Cruz, California, in August 1988. The research topics include surveys of galaxies and quasars, variability among active galactic nuclei, x-rays and central sources, black holes, gravitational lenses, the structure of the central objects in active galaxies, and the environment of the active nucleus.

General Astronomy

ANALOG Essays on Science, edited by Stanley Schmidt, (John Wiley and Sons, 1990), ISBN 0-471-50839-X, hardcover, 280 pages, $19.95.

Stanley Schmidt, editor of the science fiction monthly *ANALOG,* has published a selection of popular science essays that appeared in the magazine during the past decade. The essays cover a broad range of ideas on subjects as diverse as genetics, human evolution, the origin of the universe, interstellar travel, and alien sex.

Astronomy: A Journey into Science by Karl F. Kuhn, (West Publishing, 1989), ISBN 0-314-47009-3, hardcover, 775 pages, $46.25.

This is the first edition of a new astronomy textbook for college students enrolled in introductory astronomy courses. The book presents the usual topics — the solar system, galactic and extragalactic astronomy, and cosmology. Kuhn, however, also stresses the scientific processes involved in astronomy, what he calls "the logic of science." The textbook is heavily illustrated, is low on jargon, defines most new terms in the margins, and contains a number of appendices on such topics as celestial coordinates, planetary orbits, and the nearest and brightest stars. The book should interest amateur astronomers who want an up-to-date reference book.

The Scientific Companion by Cesare Emiliani, (John Wiley and Sons, 1988), ISBN 0-471-62484-5, softcover, $14.95.

The Scientific Companion is a compendium of scientific facts, figures, constants, and equations, as well as articles on space and time, atomic structure, the Sun, stellar evolution, the formation of the universe, and the origin of life on Earth. The appendix contains tables of information that science students and enthusiasts will refer to time and again: constants, conversion factors, elements, the Greek alphabet, and definitions of units (radian, newton, astronomical unit, megaparsec, etc.). The book is well illustrated and written in a non-technical style.

The Thousand-Yard Model: Or, The Earth as a Peppercorn by Guy Ottewell, (Astronomical Workshop, Furman University, Greenville, SC 29613), ISBN 0-934546-21-5, brochure, 15 pages, $5.00.

Guy Ottewell, author of the annual *Astronomical Calendar* has recently published a booklet designed to help science teachers and astronomy lecturers convey the overall size of the solar system. Ottewell explains how to demonstrate the distances to the planets and the nearest stars by using such everyday items as balls, peppercorns, peanuts, coffeebeans, and even people as models of solar system objects. He also describes models for larger and smaller scale solar systems, and how to impart some sense of the distances to the nearest stars.

Solar Astronomy

Energetic Phenomena on the Sun, edited by M.R. Kundu, B. Woodgate, and E.J. Schmahl, (Kluwer, 1989), ISBN 0-7923-0172-2, hardcover, 632 pages, $139.00.

Energetic Phenomena on the Sun comprises technical papers given during a workshop held in 1983 at Goddard Space Flight Center. One of the main thrusts of the workshop was to synthesize three years of flare studies from the *Solar Maximum Mission* satellite, as well as present the latest data on solar flares since the *Skylab* mission.

Space

The Air and Space Catalog: The Complete Sourcebook to Everything in the Universe edited by Joel Makower, (Random House, 1989), ISBN 0-679-72038-3, softcover, 332 pages, $16.95.

This is a sourcebook of listings of product information, articles, and resources for amateurs and experts involved in astronomy, weather, spaceflight, and aviation. The book also contains short articles on Earth's changing atmosphere, UFOs, archeoastronomy, and choosing a telescope.

The astronomy section features listings of North American observatories, planetariums, and clubs. Also included is a list of telescope manufacturers, with addresses and price ranges. □

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Planetary Nebula Enhancement Filter, (Chris Bayus, Genesee Astronomical Society, care of Robert T. Longway Planetarium, 1310 E. Kearsley Street, Flint, MI 48503), $5.00.

One of the best filters available for observing planetary nebulae is transparent to the dominant emission of these objects — doubly ionized oxygen, or oxygen III, which peaks at 496 nanometers. Such a wavelength-specific filter, however, is expensive to produce and usually costs in the neighborhood of $100 or more.

A $5.00 alternative is the planetary enhancement filter offered by Chris Bayus, an amateur astronomer from Genesee, Michigan. This slide-mounted green-gelatin filter, which you hold between your eye and the eyepiece, allows the peak emission of light from planetary nebulae to pass through while it blocks or inhibits other wavelengths. The result is a slight boost in image contrast.

Bayus does not claim that his filter is a breakthrough or that it is in the same class as commercial oxygen III filters. He merely claims his filter slightly enhances the view of some bright planetary nebulae, and that's exactly what it does.

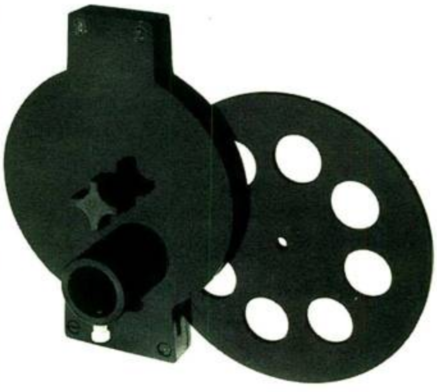
I observed planetary nebulae of various sizes and brightnesses in relatively light-polluted skies and found that the "presence" of these objects in the field of view was slightly increased with the filter. The filter also seemed to work better with more extended objects. For example, subtle details within the Dumbbell and Owl nebulae were a bit more apparent with the filter than without. Compact planetaries like the Eskimo, however, showed little or no improvement, even at high power.

The filter won't disappoint you as long as you don't expect it to do the work of an oxygen III filter. For budget-minded deep-sky observers looking for even a slight advantage over light pollution, this option seems well worth the modest price. — *Jeff Kanipe*

OBSERVING ACCESSORIES

Multi-Filter Wheel, (Optical Research Corporation, 3009 East Forest, Appleton, WI 54915; (414) 734-5006), $149.00 for 1 1/4-inch model, $169.00 for 2-inch model.

If you've ever fumbled with multiple filters, switching back and forth between red and blue filters for planetary viewing or between various nebula filters for deep-sky observing, then Optical Research Corporation has the product for you. Their new Filter Wheel can hold up to eight different filters. The unit consists of two parts: a frame that slides into the telescope's focuser and that accepts eyepieces, and an interchangeable wheel that rotates to insert each filter into the light path.



SWITCH FILTERS EASILY with Optical Research Corporation's new Multi-Filter Wheel.

The unit has a built-in 2x Barlow lens from University Optics. This compensates for the thickness of the Filter Wheel and allows eyepieces to reach focus on telescopes like Newtonians. A model without the Barlow is available for owners of Schmidt-Cassegrains and other telescopes with generous focus travel.

Filter Wheel models are available for 1 1/4-inch focusers (with a wheel for eight 1 1/4-inch filters) and for 2-inch focusers (with a wheel for four 2-inch filters). The 2-inch model also accepts the eight-filter wheel. Spare wheels, which allow the user to have even more filters at the ready, can be purchased separately.

Smart Chart II, (Roger W. Tuthill, Inc., 11 Tanglewood Lane, Mountainside, New Jersey 07092; (800) 223-1063, FAX (201) 232-3804), $195.00; Personal check, credit card, or COD accepted.

The Smart Chart is a computerized pocket reference unit that provides key facts about deep-sky objects. The up-

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THE SMART CHART II, designed for use at the telescope, complements the use of digital setting circles.

graded model II features epoch 2000.0 coordinates and has an expanded list of reference stars. The unit displays the catalog number, RA and Dec. coordinates, object type (from one of seven types), and magnitude for any of the 7,500 objects in its database. Included is data on all Messier objects, the Revised New General Catalog objects (with numerous data corrections and with non-existent objects deleted), as well as nineteen bright reference stars. You can search all 7,500 objects by magnitude limit, object type, NGC number, Messier number, or Right Ascension.

The Smart Chart weighs less than 8 ounces and can fit into a shirt pocket. It has a five-button control panel with a red LED display. When it's turned off a battery-backed CMOS memory saves the current setting, allowing you to resume searching the database where you left off.

SOFTWARE

Voyager 1.2, (Carina Software, 830 Williams Street, San Leandro, CA 94577; (415) 352-7328), for Macintosh computers, $124.50, upgrades for version 1.0 owners available for $30.00 plus shipping.

Voyager is a computer program that allows you to explore the past, present, and future sky from any point on the surface of Earth or within the solar system. Version 1.0 was reviewed in the March 1989 issue.

The upgraded version adds many new features: a 360° celestial sphere view; an Earth globe graphic for selecting observing locations; the ability to determine sky coordinates from digital readouts of the cursor position; coordinate grid overlays that can be switched between equatorial, altazimuth, ecliptic, and galactic grid systems; custom horizons to match your observing location; indicators of the zenith, celestial poles, ecliptic poles, and galactic poles; and star search capabilities by Yale number, Flamsteed number, or Greek letter/constellation designation.

In addition, version 1.2 allows you to search for conjunctions of the planets, Sun, and Moon over centuries of time; display planets as disks with correct pole orientation, phase, and ring system; watch the progress of lunar eclipses; watch the Moon's shadow cross Earth's disk during a solar eclipse; follow the 26,000-year precession cycle; define and plot the orbits of several asteroids, comets, and space probes; and plot a moving perspective view of stars within 30 light-years of the Sun.

Version 1.2 of *Voyager* requires a minimum of 1 megabyte of RAM and is compatible with Multifinder.

PHOTO SERVICES

Computer False Color Enhancement, (AstroEnhance, 719 S. Harbor Boulevard, Drawer 222, Fullerton, CA 92632), $19.95 per slide plus $2.50 for postage and handling.

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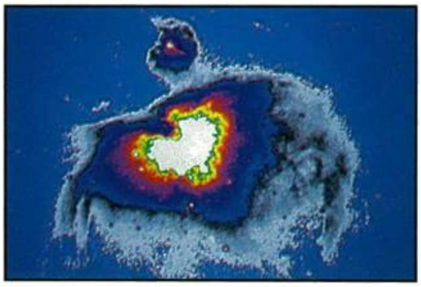

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FOR SALE — Meade equatorial mount clock drive with setting circles. for use with 6" or 8" telescope. $250. Contact Brad Saunders, RFD #1, Hebron, ME 04238. Phone: (207) 966-3653.

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FOR SALE — Hundreds of magazines, including ASTRONOMY, *Sky & Telescope, Odyssey,* and others. For lists send SASE to Tony Landin, 7334 Larch Hall, ISU, Ames, IA, 50013. Phone: (515) 294-9219.

FOR SALE — BK-7, grade 'A' blank, 135.4mm diameter, 23.7mm thick, made by Schott. $75. Contact Gary R. Phelps, 226 High Avenue, Oshkosh, WI 54901. Phone: (414) 233-1699.

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June 2
Public Star Party, Carolina Beach State Park, North Carolina. Sponsored by the Cape Fear Astronomical Society. Contact: Cape Fear Astronomical Society, 110 Linville Drive, Castle Hayne, NC 28429.

June 8-9
20th Annual Apollo Rendezvous and Telescope Fair, Dayton, Ohio. Sponsored by the Miami Valley Astronomical Society and the Dayton Museum of Natural History. Contact: Ian Dumbauld, 5932 Culzean Drive #706, Dayton, OH 45426.

June 15-17
Jersey Star Quest, Rutgers 4-H Camp, Beemerville, New Jersey. Sponsored by the Amateur Astronomers' Association of Princeton. Contact: Amateur Astronomers' Association of Princeton, P.O. Box 2017, Princeton, NJ 08540.

June 22-24
Arbuckle Star Party, Arbuckle Observatory, near Ardmore, Oklahoma. Sponsored by the Arbuckle Astronomical Society. Contact: Arbuckle Astronomical Society, Route 1, Box 72, Tishomingo, OK 73460.

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Arkansas Star Party, near Fort Smith, Arkansas. Sponsored by the Arkansas-Oklahoma Astronomical Society. Contact: Coleman Memorial Observatory, Route 1, Box 404, Hackett, AR 72937.

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Astronomical League Northeast Regional Convention, Mount Holyoke College, South Hadley, Massachusetts. Sponsored by the Springfield Stars Club and the Amherst Area Amateur Astronomers Association. Contact: George Bottasso, 21 Princeton Avenue, Feeding Hills, MA 01030. Phone: (413) 786-1339.

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Front Range Astronomical SuperCluster Star Party, Badger Flats, Colorado. Sponsored by the Colorado Springs and Denver Astronomical Societies. Contact: Robert Stencel, University of Colorado, Campus Box 391, Boulder, CO 80309. Phone: (303) 492-4050.

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Mason-Dixon Star Party, York, Pennsylvania. Contact: Bob Wolpert, York County Parks Astronomical Society, 42 Leader Drive, Jacobus, PA 17407. Phone: (717) 428-1965.

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3rd Annual Wisconsin Observers' Weekend, Hartman Creek State Park, Waupaca, Wisconsin. Sponsored by the Northeast Wisconsin Stargazers. Contact: Don Wyman, 1815 Kienast Avenue, Oshkosh, WI 54901. Phone: (414) 233-3083.

June 30
You and the Universe, Carleton University, Ottawa, Canada. A public symposium sponsored by the Royal Astronomical Society of Canada. Contact: The R.A.S.C., 136 Dupont Street, Toronto, Ontario, Canada M5R 1V2.

July 13-15
Symposium on Automated Telescopes and Global Networking, Boston University, Boston, Massachusetts. Contact: Meeting Information, Astronomical Society of the Pacific, 390 Ashton Avenue, San Francisco, CA 94112.

July 13-18
Astronomical Society of the Pacific Annual Meeting, Boston University, Boston, Massachusetts. Contact: Meeting Information, Astronomical Society of the Pacific, 390 Ashton Avenue, San Francisco, CA 94112.

July 14-15
The Universe in the Classroom, Boston University, Boston, Massachusetts. Contact: Workshop Information, Astronomical Society of the Pacific, 390 Ashton Avenue, San Francisco, CA 94112.

July 20-21
Astronomical League Northwest Regional Convention, Table Mountain, Ellensburg, Washington. Contact: Tom Jenkins, South 3312 Pittsburgh, Spokane, WA 99203. Phone: (509) 838-1381.

July 20-22
20th Annual NFCAAA Summer Seminar, Darling Hill Observatory, Vesper, New York. Sponsored by the Syracuse Astronomical Society, Inc. Contact: John Rusho, Box 19, RD 7, Fulton, NY 13069. Phone: (315) 592-5866 (evenings and weekends).

July 24-28
First European Meeting of the American Association of Variable Star Observers, Brussels, Belgium. Contact: Janet A. Mattei, AAVSO, 25 Birch Street, Cambridge, MA 02138.

July 27-28
Stellafane, Springfield, Vermont. Contact: Stellafane, 60 Victoria Road, Sudbury, MA 01776.

July 31-August 4
Astronomical League National Convention, Washington University, St. Louis, Missouri. Sponsored by the St. Louis Astronomical Society. Contact: Steve Best, 6943 Amherst Avenue, University City, MO 63130; or Wayne Clark, 310 Calvert Avenue, Webster Groves, MO 63119.

August 17-18
Starfest '90, Riverplace Campground, Mount Forest, Ontario. Sponsored by the North York Astronomical Association. Contact: Andreas Gada, 26 Chryessa Avenue, Toronto, Ontario, Canada M6N 4T5. Phone: (416) 761-1798.

August 17-19
Front Range Astronomical SuperCluster Star Party, Fox Park, Wyoming. Sponsored by the Cheyenne and Denver Astronomical Societies. Contact: Robert Stencel, University of Colorado, Campus Box 391, Boulder, CO 80309. Phone: (303) 492-4050.

August 17-19
Northwoods Starfest, Eau Claire Youth Camp, Beaver Creek Reserve, Wisconsin. Sponsored by the Chippewa Falls Astronomical Society. Contact: Kevin Litten, 921 West Willow, Chippewa Falls, WI 54729. Phone: (715) 726-2382.

August 17-19
2nd Annual Southern Minnesota Sky Show, near New Ulm, Minnesota. Sponsored by the Minnesota Valley Amateur Astronomers. Contact: Minnesota Valley Amateur Astronomers, Route 4, Box 15A, New Ulm, MN 56073.

August 17-20
Nova East '90 Star Party, Fundy National Park, New Brunswick. Contact: Halifax Centre of the R.A.S.C., 1747 Summer Street, Halifax, Nova Scotia, Canada B3H 3A6.

August 17-24
Meteor '90 Convention, Ráktanya, Hungary. Sponsored by the Hungarian

Astronomical Association. Contact: Hungarian Astronomical Association, 1253 Budapest, P.O. Box 36, Hungary.

August 22-26
Mount Kobau Star Party, near Osoyoos, British Columbia. Contact: Peter Kuzel, 4100 25th Avenue, Vernon, British Columbia, Canada V1T 1P4. Phone: (604) 545-1226.

August 24-26
4th Annual Astronomy Rendezvous and Conference, Normal, Illinois. Sponsored by the Twin City Amateur Astronomers. Contact: Twin City Amateur Astronomers, P.O Box 755, Normal, IL 61761.

September 8
StarConn '90, Wesleyan University, Middletown, Connecticut. Sponsored by the Astronomical Society of Greater Hartford. Contact: Suzanne Marinan, 367 Suger Hill Road, Tolland, CT 06084-2116.

September 14-16
Astrofest '90, Kankakee River State Park, Kankakee, Illinois. Sponsored by the Chicago Astronomical Society. Contact: Astrofest, P.O. Box 596, Tinley Park, IL 60477.

September 18-23
Okie-Tex Star Party, Lake Murray State Lodge, near Ardmore, Oklahoma. Sponsored by the Oklahoma City Astronomy Club. Contact: Okie-Tex Star Party, c/o Beryl Cadle, 6616 NW 20th, Bethany, OK 73008.

October 19-20
Twin Lakes Star Party. Sponsored by the West Kentucky Amateur Astronomers. Contact: Jim Boren, Land between the Lakes, Golden Pond, KY 42211-9001. Phone: (615) 232-7405 (days), (615) 232-6820 (evenings).

July 8-12, 1991
Research Amateur Astronomy Symposium, La Paz, Baja California Sur, Mexico. Contact: Corporation for Research Amateur Astronomy, P.O. Box 16542, San Francisco, CA 94116. ☐

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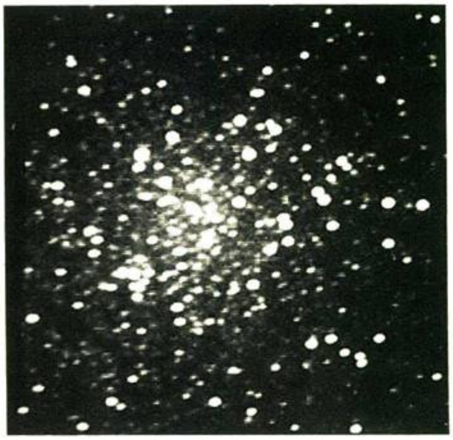

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Readings and Resources

COBE's Perfect Universe (page 20)

The Big Bang by Joseph Silk, (W.H. Freeman, 1989). One of the best popular accounts of Big Bang cosmology. Chapters 8 and 9 are relevant to the cosmic background radiation and galaxy formation.

The Magnetic Milky Way (page 32)

Interstellar Matters by Gerrit L. Verschuur, (Springer-Verlag, 1989). An account of the discovery of dark matter between the stars, the material that is shaped in part by magnetic fields. Traces our knowledge of interstellar matter from E.E. Barnard to the present.

The Invisible Universe Revealed by Gerrit L. Verschuur, (Springer-Verlag, 1987). In this work Verschuur presents the story of radio astronomy, its discoveries and techniques.

Nebulosities of Cygnus (page 64)

Atlas of Deep-Sky Splendors by Hans Vehrenberg, (Cambridge University Press, 1983). A beautiful picture book of full-page plates that shows hundreds of deep-sky objects to the same scale for easy comparison. Paging through the Cygnus sections gives an immediate indication of the relative sizes and appearances of nebulae in Cygnus.

Burnham's Celestial Handbook by Robert Burnham, Jr., (Dover Publications, 1978). A three-volume compendium of data on deep-sky objects.

Beneath the Neon Lights (page 70)

Nightwatch: An Equinox Guide to Viewing the Universe by Terrence Dickinson, (Camden House, 1989). Popular-level guide to amateur astronomy with a small telescope. ☐

CREDITS

Cover: Canada-France-Hawaii Telescope Corporation; *page 4:* Jim Baumgardt; *page 12:* M. J. Martres, Paris Observatory; *pages 20-21:* illustration by Paul DiMare; *pages 22-23:* NASA; *page 23:* diagram courtesy of John Nather, Goddard Space Flight Center; *page 24:* Margaret Geller, Harvard-Smithsonian Center for Astrophysics; *page 25, 26-27:* Changbom Park and J. Richard Gott, Princeton University; *page 28-29:* Bruce Elmegreen, Thomas J. Watson Research Center; *page 30:* Palomar Mountain Observatory; *pages 32-33:* illustration by Michael Carroll; *page 35:* ©1985, Anglo-Australian Telescope Board; *page 36:* Ed Fomalont, National Radio Astronomy Observatories; *page 37, top:* Don Mathewson, Mt. Stromlo Observatory, *left:* G.D. van Albada, J.M. van der Hulst, and J.H. Oort; *page 39:* M. Tsuboi, M. Inoue, T. Handa, Y. Sofue, and N. Kaifu of the Nobeyama Radio Observatory, and H. Tabaka and T. Kato of Utsunomiya University; *page 46:* Mace Hooley (15mm lens, Tech Pan 2415 film, 40-minute exposure); *page 48:* Jack Newton (2-inch cold camera, Konica 3200 film, 8-minute exposure); *page 49:* map adapted from *Uranometria 2000.0* by Wil Tirion, Barry Rappaport, and George Lovi, ©1987 Willmann-Bell, Inc.; *page 52:* Chris Becker; *pages 53-58:* Robert Burnham; *pages 60-62:* illustrations by Greg Kot; *page 64, top:* sketch by Jeff Corder (composite of several observations, 12.5-inch f/4.5 reflector at 35x and 150x), *bottom:* Jack B. Marling (50mm f/2.8 lens, Fujichrome 400 film developed as a negative, 35-minute exposure with Deep-Sky filter); *page 65:* Tony Hallas and Daphne Mount (5-inch f/8 refractor, hypersensitized Konica 400 120-size film, 80-minute exposure); *page 67, top:* Brant Nelson (8-inch f/1.5 Schmidt camera, hypersensitized Tech Pan film, 20-minute exposure with #92 red filter), *bottom:* Walter E. Hamler (8-inch f/5 reflector, 103a-F film, 45-minute exposure); *page 68, top:* Scott Hicks (12.5-inch f/4.8 reflector, Konica 400 film, 40-minute exposure), *center:* Martin C. Germano (8-inch f/5 reflector, hypersensitized Tech Pan film, 45-minute exposure), *bottom:* Jack Newton (25-inch f/5 reflector, Ektachrome 400 film); *page 69:* Ronald E. Royer, tricolor composite photograph; *pages 70-71:* Jerry Schad (200mm f/2.8, Kodachrome 64 film); *page 71:* Moon sketch by Marc Daniels, Saturn sketch by Michael Sweetman (4-inch f/8.6 refractor at 250x, #12 yellow filter); *page 72:* Glenn Lambert (400mm f/6.3, Ektachrome 400 film, 2-second exposure); *page 75, top:* Howard Moore III (20-inch f/4 reflector at various powers), *bottom:* Jack B. Marling (17.5-inch f/4.5 reflector, Fujichrome 400 film developed as a negative, 50-minute exposure with a Deep-Sky filter); *page 76-77:* Larry Landolfi (28mm f/4 lens, Kodachrome 64 film, 10-second exposure); *page 76, bottom left:* Gordon Garcia (8-inch SCT at f/84, Tech Pan film, 1/500-second exposure), *bottom right:* H. C. Ng; *page 77, bottom left:* Terry Smith (4-inch f/5 refractor at 170x, January 7, 1990), *bottom right:* Gregory Terrance (16-inch reflector at f/125, Tech Pan film, February 10, 1990); *page 78, top:* Chrisantha Fernando (6-inch reflector at various powers), *bottom:* Philip W. Budine (3.5-inch Maksutov telescope at 160x and 200x, and a 4-inch f/15 refractor at 167x and 214x).

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